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NORMAL PERFORMANCE IN THE TAPPING TEST

BEFORE AND DURING PRACTICE, WITH SPECIAL REFERENCE TO FATIGUE PHENOMENA

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This is an attempt to further standardize a psychological measure of a relatively high degree of simplicity, precision, and responsiveness. The measure is that of the maximum rate of repeated voluntary movements, as described and reviewed in a previous paper.[1] The taps are executed upon a telegraph key which is in circuit with a Porter signal magnet recording on smoked paper upon the 50 cm. drum of a standard Ludwig-Baltzar kymograph. The speed of the drum is approximately 13 mm. per second, the second intervals being directly recorded by a Jaquet chronograph adjusted to the pen of the magnet. The subject is left free to choose the preferred method of tapping, care being taken to see that the method is not essentially altered during the experiment. Attention has been called to sources of error in this freedom of procedure but these can hardly be obviated without introducing other and more important errors. Then too, an important object of the experiments was to obtain normal data for comparison with pathological cases unamenable to more rigid experimental control.

The conduct of the experiment is as follows. The subject begins at a given signal and taps at the maximum rate until a record of 30 seconds is obtained, when he receives a signal to stop. Then follows a 2′ 30″ pause, after which a second series is executed, then another 2′ 30″ pause and so on until five series of 30″, each with an intervening pause of 2′ 30″

[1] *American Journal of Psychology*, Vol. XIX, 1908, pp. 345-58.

have been obtained. A similar record of five 30″ series is then made with the left hand, and in repeated experiments the hands alternate in precedence from experiment to experiment. The subject refrained from muscular effort during the pauses, except that in the experiments in which the writer played the rôle of both subject and operator, the spring of the kymograph was wound with the other hand than that used for the tapping. The 2′ 30″ pause was practically a chance selection, and no attempt has been made to determine the relative influence on the test of pauses of shorter or longer duration.

The experiment is evaluated by counting the number of times the key is struck and the circuit closed during each of the six intervals of 5 seconds in the 30 seconds tapping. If, as sometimes happens, it can be established that the key was struck without closing the circuit, this is counted as a tap. The period of 5 seconds was selected because it has been that most frequently used by previous investigators of the test, and we know more about it in terms of 5 second performances than in any other terms. From the writer's results, which extend considerably beyond the material to be reported here, it is doubtful if any more efficient system of evaluation could be selected for the purposes in hand. To illustrate more clearly the precise method of dealing with the data there may be quoted in full the figures of a sample record with the right hand upon a normal individual, near the limit of practice.

	1st Interval 0–5″	2nd Interval 5″–10″	3rd Interval 10″–15″	4th Interval 15″–20″	5th Interval 20″–25″	6th Interval 25″–30″	No. of Taps in each Series
1st Series	41	37	35	34	34	32	213
2nd Series	41	37	36	35	34	34	217
3rd Series	40	39	37	37	35	34	222
4th Series	40	39	37	36	36	35	223
5th Series	41	39	38	37	36	36	227
Average of Intervals	40.6	38.2	36.6	35.8	35.0	34.2	

"Total Efficiency" of Record **220.4.**

Each of the thirty 2-place figures gives the number of taps executed in an interval of 5 seconds. Reading the top line from left to right we obtain a gradual decrease in the size of the figures, indicating a slowing up in the tapping rate. The right hand figure of three integers, 213, gives the sum of the preceding figures for the six intervals, *i. e.*, the number of taps for the whole 30 seconds. Each successive line may be read in the same way. Considering the figures in column, we obtain the figures of two digits and a decimal on the bottom line (40.6, 38.2, 36.6, 35.8, 35.0, 34.2) the average number of taps executed during the first 5 seconds, the second 5 seconds, etc. Naturally, a regular decrease is noted. The figure in heavy-faced type, **220.4**, gives the average of the five three-digit figures above it, *i.e.*, the average number of taps executed each time during the five 30 second series. This figure is taken as indicating the "total efficiency" of the function in that record, subject, of course, to the variability of the single series it represents. Subsequently, therefore, unless otherwise evident, a two place integer may be taken to represent a number of taps done in a single interval of 5 seconds, a figure of two places and a decimal to represent the verage of number of taps in five cases of a certain 5 second interval. A three place integer indicates a number of taps in a series of 30 seconds, a three place integer with a decimal indicates the average performance in five such series, the total efficiency of the record. Six successive 5″ *intervals* thus form a *series*, five 30″ series a *record*, and the two records of right and left hand constitute the single *experiment*.

The material upon which the present study is based consists of eighty such experiments. Two experiments each were made upon ten normal individuals, and thirty experiments each upon two individuals. One of the subjects in the thirty experiments was the writer; the other was Mr. F. W. Kinsman, a nurse in the hospital, the fidelity of whose co-operation is quite as evident in the figures of his results as it could be made by verbal assurances.

The experiments upon the ten normal subjects were made between 8 A. M. and 2.30 P. M., and the second test was made at the same time of the day as the first, one week later, except in the case of Subject H, in whom the intercurrence of a sprained wrist necessitated a longer interval. The practice curve of the writer consisted of thirty daily experiments broken by intermissions of two weeks after the 14th, and 10 days after the 24th and 26th days. The routine in the other subject was similar, save that his first two days are taken from the records of the ten normal subjects, of whom he was also one. The time of day was not so rigidly controlled as in the

ten subjects, but it fell between 7.45 and 9 A. M. for the former, and between 8 and 10 A. M. for the latter subject. There is evidence that no significant error is induced by this variation.[1]

Inasmuch as the material is to be considered from a number of often only indirectly related points of view, the scope of the discussion may be made clearer by the following enumeration of the points to be brought out. The portions of the study dealing with these various topics have corresponding headings and the main findings on each point are similarly summarized at the close of the paper.

1. Individual differences in "Total Efficiency."
2. Index of right-handedness.
3. Rate in the successive series, "warming up."
4. Rate in the successive intervals, fatigue.
5. Fatigue and individual variation.
6. Total efficiency practice for the two subjects.
7. Relative practice of right and left hands.
8. The effect of practice upon the "warming up" phenomenon.
9. Practice and the successive intervals.
10. The influence of intermissions upon practice gain.
11. The effect of "warming up," as brought out by practice, on the different intervals.
12. An "index of fatigue."
13. Correlation of the fatigue phenomena in the different hands.
14. The relative fatigability of right and left hands.
15. The correlation of fatigability and initial rate.
16. The effect of practice on fatigability.
17. Variability.
18. The subjective condition as related to gross rate and fatigability.

1. Individual Differences in "Total Efficiency." The following table gives for the ten subjects the gross rate in terms of number of taps in a series of 30 seconds, without reference to fatigue phenomena. The series for each hand are arranged in columns of five, according to their order in the record. The figures in heavy faced type give the averages of the figures above or preceding them, according as we consider the average rate of each subject, or the average of the first, second, third, fourth or fifth series in all ten subjects. Thus the aver-

[1]Since the practice of Subject I was necessarily with knowledge of immediate results, it was considered desirable that Subject II should also have an equal knowledge. The present practice is, therefore, "with knowledge of results," but only to the extent of a knowledge of the gross practice gain.

TABLE I.

GROSS RATES IN TEN NORMAL INDIVIDUALS. NUMBER OF TAPS IN 30 SECONDS.

Subject	A	B	C	D	E	F	G	H	J	K	Av.	M. V.
First Experiment, Right Hand.												
1st Series	218	153	182	198	192	201	175	216	209	180	**192.4**	*16.0*
2nd "	217	156	175	197	187	195	187	209	201	181	**190.5**	*13.3*
3rd "	221	156	174	201	191	207	192	206	205	185	**193.7**	*14.6*
4th "	229	156	204	204	195	204	189	212	209	186	**198.8**	*13.8*
5th "	209	155	182	215	191	205	192	215	206	186	**199.2**	*14.4*
Average	**218.8**	**155.2**	**183.4**	**203.0**	**191.2**	**202.4**	**187.0**	**211.6**	**208.0**	**183.6**	**194.9**	
M. V.	*5.0*	*1.0*	*8.0*	*5.2*	*1.8*	*3.6*	*4.8*	*3.2*	*2.0*	*2.2*	*3.7*	

age of Subject E's, five series of taps with the right hand in the first experiment is **191.2,** in the second experiment is

TABLE I. (Cont.)

Second Experiment, Right Hand.

Subject	A	B	C	D	E	F	G	H	J	K	Av.	M. V.
1st Series	216	147	163	200	199	205	193	212	200	175	**189.0**	*20.9*
2nd "	225	150	158	202	193	202	193	210	204	175	**191.4**	*18.0*
3rd "	239	158	160	202	197	207	202	206	200	180	**195.1**	*17.5*
4th "	242	147	162	208	207	208	203	211	204	178	**197.0**	*20.8*
5th "	234	151	160	207	207	207	192	214	205	182	**195.9**	*19.7*
Average	**231.2**	**150.6**	**160.6**	**203.8**	**200.6**	**205.8**	**196.6**	**210.6**	**202.6**	**178.0**	**193.7**	
M. V.	*8.6*	*3.2*	*1.6*	*3.0*	*5.2*	*1.8*	*4.8*	*2.0*	*2.0*	*2.4*	*2.5*	
First Experiment, Left Hand.												
1st Series	200	132	159	185	167	163	173	198	181	171	**172.9**	*14.3*
2nd "	202	127	161	175	166	166	185	186	185	170	**172.3**	*14.3*
3rd "	206	131	159	171	179	173	170	188	188	174	**173.9**	*13.1*
4th "	203	123	162	173	174	166	175	191	190	167	**172.4**	*14.4*
5th "	199	120	152	176	177	176	177	200	188	168	**173.3**	*16.1*
Average	**202.0**	**126.6**	**158.6**	**176.0**	**172.6**	**168.2**	**176.0**	**192.6**	**186.4**	**170.0**	**173.0**	
M. V.	*2.0*	*4.0*	*2.4*	*3.4*	*4.8*	*3.8*	*4.0*	*5.2*	*2.8*	*2.0*	*3.4*	

TABLE I. (Cont.)

Second Experiment, Left Hand.

Subject	A	B	C	D	E	F	G	H	J	K	Av.	M. V.
1st Series	209	138	153	188	187	177	172	197	191	170	**178.2**	*16.8*
2nd "	207	135	159	177	185	167	169	194	190	165	**174.8**	*15.8*
3rd "	221	127	155	180	185	179	171	197	191	167	**177.3**	*17.7*
4th "	213	128	155	169	198	174	174	196	189	163	**175.9**	*19.4*
5th "	220	133	154	177	182	174	168	191	188	165	**175.1**	*15.7*
Average	**214.0**	**132.2**	**155.2**	**178.0**	**187.4**	**174.2**	**170.8**	**195.0**	**189.8**	**166.0**	**176.3**	
M. V.	*5.0*	*3.8*	*1.4*	*4.6*	*4.2*	*3.0*	*1.8*	*2.0*	*1.0*	*2.0*	*2.9*	

200.6, but the average number of taps of all subjects during the first series for the right hand is **192.4** in the first experi-

ment and **189.0** in the second. Let us first consider the gross rates of the various subjects as given in the heavy faced figures running horizontally across the table.

It is difficult to estimate the range of individual differences because the limit is not well defined. The rates of rhythmic discharge in tonic contractions obtained by Schaefer and others have been surpassed in repeated voluntary movements. The fastest initial rate on record is, I believe, about 15 per second. Our rates here are much slower, the fastest and slowest subjects, who happen to be the first two quoted, vary as about 3:2. With a greater number of subjects, we should doubtless have increased this range.

It will be remembered that Bolton, working with large groups of children found a group correlation between a general superiority of make-up and the gross rate of tapping. Bagley did not find it for class standing. What correlations in this respect may obtain for groups, the present observations are not of a character to say, but as between individuals they are altogether insufficient to serve as a basis for deductions as to any phase of physical or psychical constitution. W. G. Smith[1] mentions that among his fastest subjects were epileptic dements; the fastest record but one obtained by the writer is from a well developed case of general paralysis. The writer has observed a few individuals who, tapping unusually fast, without special practice, were of highly "nervous" temperament, but equally "nervous" temperaments may be found among those whose maximum rate is below the average.

What is the precise physiological significance of the maximum rate is by no means well made out, and cannot be deeply entered into here. It seems to be generally conceded that it is limited by the refractory phase of the synapses in the motor pathways, but that does not make the tapping test a measure of the period of this refractory phase; at least not in the earlier stages of practice. It is probable that the measure of this period would give us data of considerable psychological significance, and it may be possible to study it through the methods described by Schaefer and others. In the later stages of practice we probably do obtain in the tapping test a measure greatly analogous to this, but in the beginning, as we ordinarily have to apply the test, the factors in speed are probably those of co-ordination mainly,[2] and cannot be expected

[1] *Br. J. Ps.*, I, 256.

[2] In so far as the graphic record of the manipulation of the telegraph key affords an analysis of the tapping movements, it brings out a rather interesting point with respect to the nature of this co-ordination. The record gives of course, the time during which the key is held down distinct from that during which it is released. In Subject

to afford information about the condition of the motor pathways as given in the refractory phase. A high gross rate in tapping does not, as has been pointed out, involve superiority in other aspects of motor speed. It may be mentioned that the writer happens to be at about the limit of practice in both the tapping test and simple reaction time. In simple reaction time (to sound and light) he has always been quite rapid; in the tapping test relatively slow. If the different aspects of motor speed do not correlate with each other, we certainly cannot expect a single aspect to give us a general idea of the individual's motor speed. The tapping test happens to be the easiest of the motor speed tests to make with a fair degree of accuracy, and it is probably as fundamental a point of individual difference as any other psychological test. At present it measures ultimately no more than it measures immediately, and indicates "voluntary motor ability" only in a very Pickwickian sense. Nevertheless the bare statistics of previous and the present experiments would seem to give assurance that there are conditions, almost certainly nervous, with which performance in this test varies from day to day and from individual to individual considerably beyond the limits of probable error. As these conditions are better made out, the gross rate will assume greater significance. At present, it is

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I the ratio of the pressed down period to the released period was about the same in right and left hands, and an immediate effect of practice was to decrease it very markedly, and about equally for both hands; that is, so far as can be judged by inspection, the key appears to be held down for a proportionately shorter period of the entire tap after practice than before. In Subject II it was also quite noticeable that the holding-down period decreased with practice in the right hand, and that it was from the beginning shorter in the right than in the left. Practice tended to make this difference more marked; the holding-down period decreased much more in the right hand than in the left. Indeed, one can hardly be sure that it decreases in the left hand at all. The length of this holding-down period varies a good deal from day to day, but as between the records of the same day, it becomes much more constant with practice. The length of this holding-down period may perhaps be taken to represent in a measure the efficiency of co-ordination, for the hand should obviously come up as soon as it touches the key; the direction of the hand's movement must be changed with as little loss of time as possible. The effect of practice is to shorten this interval, but above all to make it more constant, which latter is perhaps the truer attribute of efficiency in co-ordination. It may be mentioned that Binet and Vaschide with the myograph method found the pause between contraction and relaxation (corresponding to the holding-down period) to be longer than that between relaxation and contraction, though this result is incommensurable with the present experiments, since both movements here involve muscular contractions. With certain obvious modifications in method, the test might afford very interesting data in the improvement of rapid co-ordinations by practice.

impossible not to regard the changes in rate within the individual performance as the more important factors. Its technical advantages as a measure of fluctuation in continued work have been previously discussed.

2. *Index of right-handedness.* Woodworth has proposed an "index of right-handedness" based on the ratio of the efficiency of the left hand to that of the right. Our criterion of efficiency in this case is the average number of taps executed during five series of 30 seconds each. Dividing the average for the left hand by the average for the right, we obtain the "index." These indices for each of the ten subjects in the two experiments are as follows:

TABLE II

Subject	A	B	C	D	E	F	G	H	J	K	Av.	M. V.
First experiment (right hand preceding.)	.93	.81	.87	.87	.90	.93	.94	.91	.90	.93	**.89**	.035
Second experiment (left hand preceding.)	.93	.87	.96	.87	.93	.85	.87	.93	.93	.93	**.91**	.033

In the average the left hand does relatively better when it precedes than when it follows the right, which would be the case if the work with one hand had a fatiguing effect upon the speed of the other, but in the individual cases this is seen to be the product of certain coarse deviations in either direction, so that no general conclusion ought to be drawn. For the subjects who do remain fairly constant, however, the individual differences in the index are worth noting.

3. *Rate in the successive series, "warming up."* We may now consider the data of Table I according to the heavy-faced figures in the vertical columns, the averages of the total efficiency for each 30″ series taken by itself. In the right hand it is quite noticeable that the first two series are generally the poorest, and that there is a well-marked tendency for the later series to be faster than the earlier. To this phenomenon we may apply the name of *interserial warming up, i. e.*, a warming up from series to series, as distinct from a warming up process confined to a single series. The only trace of this latter process in normal individuals seems to be a slight increase in rate during the first second. This interserial warming up really appears

much more strikingly in the examination of the records of the individual subjects than it does in the averages, where it is entirely masked by the size of the m. v.'s. The tendency to progressive improvement can easily be traced throughout the right hand.

In the left hand it is by no means so evident that such a process exists. In the first experiment the five series average about equal in rate, and are very close together. In the second they are also quite close, the first series this time averaging the best. Some records seem to warm up, others to fatigue between the series, but on the whole the order is rather chaotic. The m. v.'s of these averages are an expression of individual difference between the subjects. It will be noted that these variations were distinctly greater in the second test than the first. This might possibly be taken to indicate that interest in the test was more nearly equal in the first than in the second experiment. Conscientiously co-operative individuals will work equally well up to their maximum at both times; on the other hand those subjects to whom novelty contributes the chief interest in the test, will co-operate better the first time than the second. Individual differences in the hands are practically equal, though they are slightly less in the left, not enough so for any special interpretation.

4. *Rate in the successive intervals, fatigue.* Let us now consider the data as presented from a different viewpoint, *i. e.*, according to the rate in each of the six successive 5″ intervals. (See Table III.) Since each series provides one of each interval, and the series are five in number to the record, each figure in the subjoined table gives the average number of taps during five cases of each five second interval. The precise way in which the figures are calculated may be understood by referring to the type record (p. 438). What 40.6, 38.2, 36.6, 35.8, 35.0, 34.2, are to the subject in the type record, 41.2, 38.8, 35.8, 35.0, 33.8, and 34.2 are to Subject A's first record with the right hand. During the first five seconds of each of his five series he averages 41.2 taps, during the second five seconds 38.8 taps, during the last five seconds 34.2 taps. As above, the figures are quoted separately for each of the two experiments. The average rates of the ten subjects for each interval as well as their m. v.'s will be found in their usual places.

Through these figures we may obtain an idea of the progressive decrease in efficiency which we term the fatigue loss. It appears that, so far as can be gathered from discrete units like the present, the curve follows the form usual to fatigue curves, the decrease being rapid at first and subsequently slower. The method is not such as to make it worth while to undertake measurements of very fine fluctuations; some

The figures are as follows :

TABLE III

RATES IN THE SUCCESSIVE INTERVALS IN TEN NORMAL INDIVIDUALS

AVERAGE NUMBER OF TAPS IN 5 CASES OF EACH INTERVAL

Subject	A	B	C	D	E	F	G	H	J	K	Av.	M. V.
First Experiment, Right Hand												
1st interval	41.2	27.6	32.8	36.2	36.4	37.2	32.0	38.6	39.0	32.4	**35.3**	*3.3*
2nd "	38.8	27.0	31.0	34.6	33.8	34.2	31.6	36.6	35.8	31.6	**33.5**	*2.6*
3rd "	35.8	26.0	31.0	33.8	31.8	33.6	31.2	35.6	34.4	30.6	**32.3**	*2.3*
4th "	35.0	25.2	29.6	33.2	30.0	33.6	30.8	34.4	33.6	30.2	**31.5**	*2.4*
5th "	33.8	24.8	29.4	32.6	29.8	32.4	31.0	33.4	33.0	29.6	**31.0**	*2.0*
6th "	34.2	24.6	29.6	32.6	29.4	31.4	30.4	33.0	32.2	29.2	**30.7**	*2.0*

TABLE III. (Cont.)

TABLE III. (Cont.)

Subject	A	B	C	D	E	F	G	H	J	K	Av.	M. V.
Second Experiment, Right Hand												
1st interval	43.8	28.0	27.0	35.8	39.0	36.0	34.2	37.8	37.4	30.6	**35.0**	*3.9*
2nd "	40.0	26.6	27.2	34.6	35.4	34.4	33.0	36.0	35.0	30.2	**33.2**	*3.1*
3rd "	37.6	24.8	26.4	34.0	33.0	33.8	33.2	35.4	34.0	29.6	**32.2**	*3.2*
4th "	36.8	23.8	27.0	33.4	31.4	33.6	32.8	34.8	32.6	29.4	**31.6**	*2.9*
5th "	37.0	24.0	26.6	33.4	31.2	34.2	31.8	33.8	32.2	29.4	**31.4**	*2.9*
6th "	36.0	23.4	26.4	32.6	30.6	33.8	31.6	32.8	31.4	28.8	**30.7**	*2.8*
First Experiment, Left Hand												
1st interval	40.8	23.6	27.6	32.2	30.2	32.0	32.4	35.8	34.2	31.2	**32.0**	*3.0*
2nd "	37.0	22.0	27.2	30.6	29.2	29.6	30.2	33.8	32.4	29.4	**31.1**	*2.9*
3rd "	33.6	20.2	26.6	29.0	29.4	28.0	29.8	31.8	30.8	28.2	**28.7**	*2.4*
4th "	30.6	20.4	26.0	28.6	28.2	27.0	28.4	31.6	29.8	27.8	**28.0**	*2.1*
5th "	30.8	20.4	25.6	28.2	27.8	26.2	28.0	29.6	29.6	26.8	**27.3**	*2.2*
6th "	29.2	20.0	25.6	27.4	27.8	25.4	27.2	30.0	29.6	26.6	**26.9**	*1.9*

TABLE III. (Cont.)

Second Experiment, Left Hand

Subject	A	B	C	D	E	F	G	H	J	K	Av.	M. V.
1st interval	42.8	24.4	26.6	32.4	34.0	32.0	30.4	35.2	35.0	29.8	**32.3**	*3.5*
2d "	38.2	23.4	26.0	30.4	33.0	30.6	30.2	34.8	32.6	28.6	**30.8**	*3.2*
3rd "	34.6	21.6	26.0	29.8	31.2	28.8	29.0	32.4	31.6	27.8	**29.3**	*2.6*
4th "	33.6	21.0	25.8	29.0	30.2	28.0	28.2	30.2	31.0	27.0	**28.3**	*2.4*
5th "	32.4	21.0	25.6	28.2	29.6	27.8	27.0	32.2	30.2	26.6	**28.1**	*2.3*
6th "	32.4	20.8	25.2	28.4	29.4	27.0	26.0	30.2	29.4	26.2	**27.5**	*2.3*

rather limited researches upon this point have already been mentioned.[1] Great individual differences in the regularity of the single taps can be seen, however, by inspection, and this is an aspect of the test that would well repay special study, though it is not within the scope of the present calculations. It may also be brought to mind that as the figures given are averages, the decreases which they represent are frequently of greater regularity than characterizes the scores for the individual series, the irregularities tending to compensate; but the averages also compensate for the error introduced by taking no account of fractions of a tap, which, when the rates are very constantly maintained, is often of no inconsiderable significance.[2]

5. *Fatigue and individual variation.* So far as gross rates are concerned, the figures of course merely restate the data given in Table I; but the m. v.'s seem to present unequivocally a point of some significance. It will be noted that they throughout tend to become progressively smaller as fatigue sets in, quite out of proportion to the decrease in gross rate. This is true of all the records.

The individual differences in the function are decreased by from 1/4 to 1/3 after 30 seconds work. *The main factor then, in giving a high gross rate to an individual at the beginning of practice is his performance in the earlier intervals.* When we are

[1]Bliss: Yale Studies, I, 45-52; Moore: Yale Studies III, 92-95.

[2]There must be mentioned in this connection a series of eight experiments with an additional mentally normal subject, with no known neurological condition, who fails entirely to show any of the principal phenomena of the tapping test indicated as normal in these and previous studies. Of co-operation, at least to the level of that reached in any of the ten normal subjects, there can be no question. The results are marked by very wide fluctuations between the intervals as well as from series to series, and even from day to day. Of fatigue phenomena, in the sense in which the term has been here used, there is no significant trace, but as has been said, there are very wide, almost chaotic fluctuations, between the intervals. Examples are such series as the following:

a.	*38*	*40*	*35*	*39*	*35*	*36*
b.	*40*	*38*	*37*	*40*	*39*	*38*
c.	*34*	*33*	*35*	*40*	*40*	*38*
d.	*36*	*36*	*36*	*36*	*38*	*36*
e.	*30*	*31*	*32*	*31*	*36*	*32*

Now and then occurs a series whose intervals resemble the familiar fatigue curve, as 34, 33, 31, 29, 29, 29, but this no oftener than might be the product of chance. Indeed, if there is any general tendency at all it is for the later intervals to be faster than the earlier, *i. e.*, they show intra-serial warming up, warming up within the series. During the eight consecutive days there is no trace of practice; indeed, the later experiments are rather slower than the earlier. The writer cannot formulate any explanation of these wholly anomalous records.

fresh, and doing the best that we shall do, we vary distinctly more from each other than when we have lost somewhat through fatigue. The nearest interpretation might again seem to be in terms of co-operativeness. The more co-operative individuals tried harder, and fatigued more quickly to the level of those who did not try so hard. In this sense however, we have to interpret co-operativeness, not in terms of consciousness, but rather as the amount of effort which the organism puts forth in response to volition. It may be said with some assurance that continued exercise of the function, besides lowering its efficiency, tends also to decrease individual differences in it.

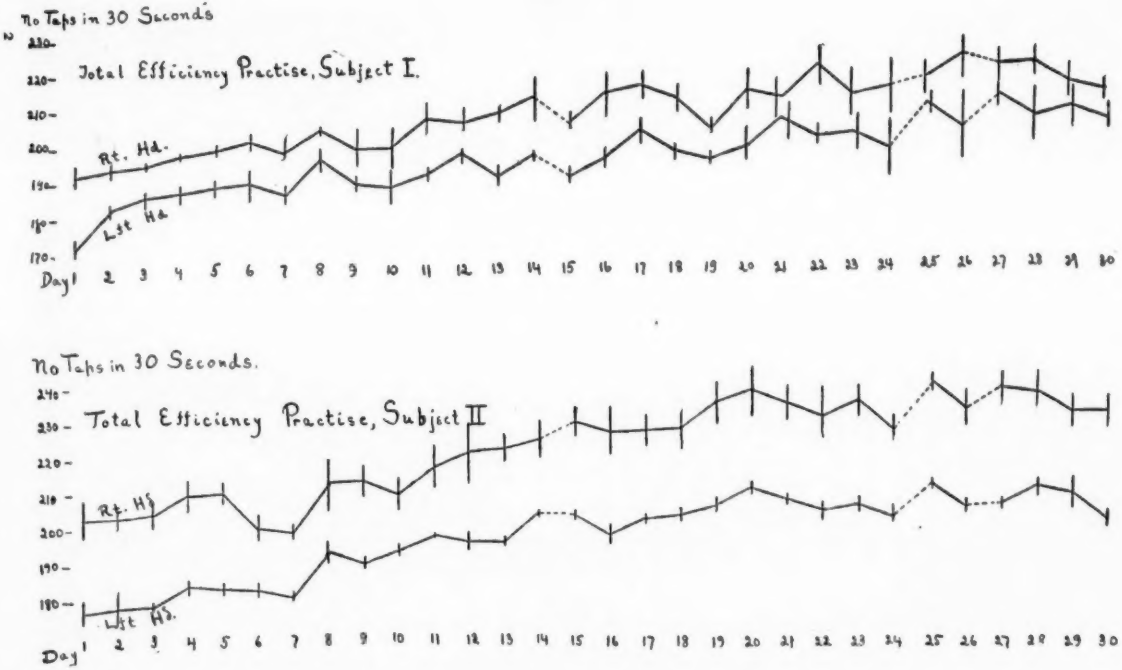
6. *Total efficiency practice for the two subjects.* Such are the general phenomena of the tapping test as they appear in ten normal individuals without special practice. We shall now observe how these conditions are modified during practice in two normal individuals. As has been said, the series on Subject I is continuous except for intentional breaks in practice, but the first three experiments on Subject II were separated by considerable intervals which do not, however, appear to affect their results. In each subject intermissions of 14 days were introduced after the 14th and of 10 days after the 24th and 26th days; this being done to study the effect of such intermissions on the practice curve. The entire curve is made up of 30 experiments.

As a basis for plotting the general course of the practice curve in the two subjects, the natural choice fell upon the "total efficiency" figure for each record, corresponding to **220.4** in the type record. The accompanying plate shows the practice curve as given for the successive thirty "total efficiency" figures. The dotted lines, here and in Plates II and III, mark the intermissions. The vertical lines give the m. v. of each total efficiency figure.

It should perhaps be mentioned that Subject I had had some relatively unsystematic practice in the test, both as a subject in other researches of which it formed a part, and in setting up the present apparatus. Subject II was quite without special practice. The curves, however, show no characteristic that could be referred to this difference.

First of all, it will be noted that the rise ot the curve is not more rapid at the beginning than elsewhere, the opposite of what we usually expect in practice curves. This is especially marked in Subject II, in whom we should expect it least, as he was without special practice; there is even a distinct drop in efficiency before a significant practice gain begins. This would seem to indicate that such unsystematic practice in this function as we receive in normal life largely eliminated the

PLATE I


No Taps in 30 Seconds
Total Efficiency Practise, Subject I.
Rt. Hd.
Lft Hd.
Day
No Taps in 30 Seconds.
Total Efficiency Practise, Subject II
Rt. Hd.
Lft Hd.
Day

marked gains so frequently seen at the beginning of practice curves. Strictly speaking, there is of course no function in which we can get the real beginning of a practice curve, any more than we can ever be really certain of having reached its end. The last ten experiments on both subjects show no especial practice gain, and so far as they go indicate the limit of practice to have been reached; but in a series of later experiments, not reported here, separated from these by an interval of nearly a month, a distinctly higher rate is obtained with Subject I. The same might or might not be true of Subject II.

7. *Relative practice of right and left hands.* Again, in neither subject does the left hand show an improvement relative to the right. In Subject I the index of right-handedness remains practically the same. In Subject II the right hand may even improve more than the left. So far as this function is concerned then, the asymmetry does not seem to be a matter of practice, at least during adult development. If it is such during earlier years, and there are so far as I know no data on this point, it might indicate that the organism is no longer sufficiently plastic to respond differently according to differences in previous training, yet it is difficult to see how under such conditions the hands would respond to practice at all, as they certainly do. At the present time the superiority of the right hand in this function seems permanently "set;" whether it was formerly otherwise is not a question which these data can answer.

In Subject I the left hand curve for the first twenty experiments follows the right very closely from day to day, rising and falling with it in every case but two (12th and 13th days), often in much the same ratio. This would indicate that the conditions bringing about a rise or fall in rate were of a general nature, since they tended to affect both hands similarly. On the 21st day, however, precisely the reverse condition begins, and is maintained to the end of the experiments save for the 30th day. The indices, as is evident below, show that the approach to this condition was gradual. When the right efficiency increases, the left decreases, and *vice versa*. It will be remembered that the precedence of the two hands alternates from day to day. Under these later conditions each hand does relatively better when it *follows* the other hand than when it precedes. It is as though the work done with the preceding hand effected a generalized warming up, contributing to the greater efficiency of the following hand.

The record of Subject II shows the same general correspondences, though with rather more frequent exceptions, seven in number. There is no evidence of the generalized warming-up

at the end, as in Subject I. On the whole, then, the tapping rate seems to be the expression of a general condition.

It will be noted that Subject I's performances for the first seven days vary very little among themselves, the curve being almost a straight line, slightly ascending. At this point we begin to encounter relatively wide fluctuations from day to day, which continue throughout the experiments. In Subject II this is also seen in the left hand; not so well in the right. Such an appearance would indicate that at the beginning a fairly constant limit was set to the maximum rate, which was later superseded by another limit of a much more variable character. The first limit may be one of co-ordination; the second, one of the actual discharge rate of the nervous impulses, but this is purely hypothetical.

From these data it follows that the index of right-handedness should not be subject to any marked increase or decrease as an effect of practice. The indices in each of the thirty experiments for both subjects are given on Table IV, p. 456.

In Subject I the average does not essentially change, and the low index in the first experiment is probably accidental. Nevertheless there is another point of interest. It may be noted that beginning with the 16th experiment the size of the index alternates quite regularly from high to low, although this is not strikingly apparent in the practice curves till the 21st day. The high index, *i. e.*, the relatively greater efficiency of the left hand occurs when the right hand precedes the left in the experiment. This is not shown by Subject II, whose indices are very constant from day to day, and indeed throughout, though they seem to rise slightly during the second five days.

The hands are very much closer together in Subject I than in II. The right hand of I does not improve in practice so much as that of II, nor does the left, if we do not consider I's first day. The difference is, however, very small, and in relation to the gross rates quite negligible.

It is safe to say that the intermissions, indicated by dotted lines, could not be located unless they had been so indicated. But while the intermissions do not essentially affect the gross rate as given in the figures here presented, they do affect the performance considerably, as more detailed considerations will subsequently show.

The m. v. of each day's series among themselves tends to increase as shown by the increase in the length of the vertical lines. Practice is ordinarily supposed to bring m. v.'s down, and it very probably does decrease that of the individual taps for short periods, but as between series and series, it introduces a warming up effect that increases their m. v. To what ex-

TABLE IV

Exp. (Day)	1	2	3	4	5	6	7	8	9	10
Subject I.	.90	.94	.96	.95	.95	.94	.93	.96	.95	.94
Subject II.	.87	.87	.87	.88	.87	.91	.91	.91	.89	.92
Exp. (Day)	11	12	13	14	15	16	17	18	19	20
Subject I.	.92	.96	.92	.92	.93	.92	.95	.93	.96	.92
Subject II.	.91	.88	.88	.91	.88	.87	.90	.89	.88	.89
(Exp. Day)	21	22	23	24	25	26	27	28	29	30
Subject I.	.97	.91	.95	.92	.97	.91	.96	.93	.97	.96
Subject II.	.88	.89	.87	.87	.88	.88	.86	.89	.90	.87

tent the increased m. v. is due to this factor may be gathered by comparing the other three curves to that of Subject II's

left hand. The warming up increase is practically absent here as is also the progressive increase in the m. v.

8. *The effect of practice on the "warming up" phenomenon.* So much for the general effect of practice on gross efficiency. In further analysis we must determine the special way in which this increase manifests itself, whether it occurs through a general increase in efficiency throughout the fatigue curve, or is mainly a heightening of the initial rate, or the giving of a progressive immunity to fatigue. Also whether the increase manifests itself differently in different series, the earlier series of an experiment not gaining so much as the later, or what not. This is the point that we shall consider first, and the data bearing upon it are given in Table V, pp. 458-9.

In this table the thirty experiments are divided into three groups of ten each, the figures in the vertical columns giving the average and m. v. of each series from day to day for each set of ten. There will at once be noted a perfectly definite tendency for the later series in each experiment to be faster than the earlier, that is, the efficiency of the hand warms up during the experiment. Inasmuch as the last series is almost always the fastest, we cannot say from these experiments how far the warming up process would extend, or how much further increase there might be.

When we observe this warming up process as it appears in the successive groups of ten experiments, it is evident that the warming up, (*i. e.*, the balance in favor of warming up over persistent fatigue) is very much accentuated by practice. In the ten normal individuals we could observe its presence in the right hand even without special practice, but by no means so distinctly as it appears in the tables here. In Subject I there was really no trace of the warming up until the fourth or fifth experiment, though in the right hand of Subject II it was quite evident from the start. The increase tends to become progressively greater with each group of ten, and the phenomenon is much more clear in the individual records than the m. v.'s of the averages would indicate it to be. The day to day variation in gross rate brings up the m. v.'s without really affecting the relation in which the different series of the same day stand to one another. This can be seen in another way. It will be noted that while the difference between the successive series of the same day (as given in the m. v., Plate I, vertical lines) tends to increase with practice, the m. v. of the same series on successive days (Table V) tends to decrease with practice; the day to day performance in each series tends more and more to form a species within itself.

The influence of practice in bringing out the warming up process could not be fully shown without printing the entire

set of series in full, which is hardly worth while; nevertheless some further demonstration of the fact may be found in the

TABLE V

Average number of Taps in each of the five successive 30″ Series, for the first 10, the second 10, and the third 10 days of the thirty experiments. The M. V. gives the day to day variations of each series.

Subject I

	Rt. Hd.						Lft. Hd.					
Days	1–10.		11–20.		21–30.		1–10.		11–20.		21–30.	
	Av.	M. V.	Av.	M. V.	Av.	M. V.	Av.	M. V.	Av.	M. V.	Av.	M. V.
1st series	194.6	3.6	204.3	3.5	209.5	4.1	184.6	3.7	194.3	2.6	197.3	5.1
2nd "	195.4	4.4	206.5	3.1	213.7	3.7	183.8	4.7	192.9	2.9	202.3	3.8
3rd "	197.7	3.9	212.7	4.3	221.5	3.7	188.4	6.2	198.9	3.7	207.7	3.1
4th "	200.8	3.1	215.4	4.8	223.6	2.2	188.9	4.5	199.5	4.0	211.9	5.5
5th "	201.1	5.5	218.6	4.5	224.9	3.7	189.1	4.7	200.2	3.4	212.7	3.1
Average	**197.9**	4.1	**211.5**	4.0	**218.6**	3.5	**187.0**	4.8	**197.2**	3.3	**206.4**	4.1

TABLE V. (Cont.)

Subject II

Days	Rt. Hd. 1–10.		11–20		21–30		Lft. Hd. 1–10		11–20		21–30	
	Av.	M. V.	Av.	M. V.	Av.	M. V.	Av.	M. V.	Av.	M. V.	Av.	M. V.
1st series	201.2	3.8	217.2	4.4	227.0	2.4	187.2	4.4	203.8	4.8	209.1	2.6
2nd "	203.5	4.5	224.6	6.0	232.9	3.9	182.2	4.6	200.7	4.5	206.3	3.9
3rd "	207.5	5.5	230.3	5.3	237.0	3.7	184.8	6.0	203.6	4.4	210.0	4.3
4th "	210.9	6.5	234.2	4.4	240.7	3.5	183.5	6.4	203.4	3.8	207.7	2.7
5th "	213.9	5.1	234.6	5.8	242.4	3.6	184.9	5.9	203.5	3.5	206.4	2.8
Average	**207.4**	5.1	**228.2**	5.2	**236.0**	3.4	**184.5**	5.5	**202.9**	4.2	**207.9**	3.3

following curves, which represent the right hand practice through the thirty days for the first and last series of each day

PLATE II

Practice curves of the 1st and 5th series of the right hand in each subject. The warming up from the 1st to the 5th series, and its accentuation by practise, are shown by the curve for the 5th series drawing away from that of the 1st series.

(corresponding to 213 and 227 in the type record), just as the practice curves previously quoted gave the average of all five series. As before, the dotted lines mark the pauses. It will be noted that the curve for the last series draws away from that of the first, showing its more rapid increase in rate. The practice gain in Subject I and in the right hand of Subject II are thus seen to consist largely in the increase in rate of the later series over the ealier.

In the left hand of Subject II this warming up is not in evidence, but this does not mean that it is absent. We must always bear in mind that we never study fatigue alone, or warming up alone, but the resultant of the two, and it is according as one overbalances the other that we speak of the work as showing "warming up" or "fatigue." It is perfectly possible that the conditions of warming up are potentially present but are overbalanced by fatigue conditions; so far as sensations go this would be borne out by the introspection of the subject, who never entirely lost a progressive sensation of fatigue in the left hand record. In Subject I the left hand showed no more tendency to fatigue sensation than the right after the first few days of practice. It will be remembered that also in the ten subjects the warming up was much more marked in the right hand than in the left. This would be in accord with the result of practice as bringing out warming up, since in these subjects also the right hand was presumably more practiced for this function than the left.

9. *Practice and the successive intervals.* Now given the result that the practice increase of the "total efficiency" figure comes in as an increase of the later series rather than of the earlier, what is the character of the gain in the intervals of the individual series itself? Is it an approximately equal gain for all intervals, is it an increase in initial efficiency or is it an increase mainly in the later intervals through growing immunity to fatigue?

With reference to this point we must consider the data in the same way as they were presented for the ten normal subjects in Table III, *i. e.*, interval by interval. The experiments have again been divided into 3 groups of 10, the averages and m. v.'s for each successive interval being given in Table VI, pp. 462-3.

10. *The influence of intermissions upon practice gain.* The most interesting aspect of practice phenomena, however, is afforded in a study of the effect of intermissions. The days after the intermissions are, as noted, the 15th, 25th, and 27th days. Referring to Plate I we see that in total efficiency these days show for Subject I a uniform loss with the right hand; with the left, however, there is a loss only with the first intermission,

TABLE VI

Number of Taps in each of the successive 5″ intervals. Average of 50 cases of each interval, 5 for each of ten days. The M. V. gives the day to day variation of the averages for the 5 cases of each interval for each day.

Subject I

Days	Rt. Hd. 1–10		Rt. Hd. 11–20		Rt. Hd. 21–30		Lft. Hd. 1–10		Lft. Hd. 11–20		Lft. Hd. 21–30	
	Av.	M. V.	Av.	M. V.	Av.	M. V.	Av.	M. V.	Av.	M. V.	Av.	M. V.
1st interval	36.4	**1.04**	39.2	**.80**	40.8	**1.06**	34.2	**1.06**	36.1	**.94**	38.1	**.76**
2nd "	34.7	**.52**	37.2	**.62**	38.8	**.50**	32.7	**.79**	34.6	**.50**	36.1	**.69**
3rd "	33.3	**.60**	35.6	**.56**	36.5	**.62**	31.2	**.72**	33.1	**.46**	34.6	**.54**
4th "	32.1	**.59**	34.0	**.72**	35.1	**.48**	30.4	**.64**	31.7	**.60**	33.3	**.50**
5th "	31.1	**.54**	33.0	**.82**	33.9	**.51**	29.5	**.73**	31.2	**.60**	32.4	**.56**
6th "	30.6	**.32**	32.3	**.78**	33.4	**.52**	28.9	**.46**	30.4	**.44**	32.0	**.58**

the other two showing considerable gains. In the curves given in Plate III, p. 471, we can analyze these gains somewhat.

TABLE VI. (Cont.)

Subject II

Days	Rt. Hd. 1–10		Rt. Hd. 11–20		Rt. Hd. 21–30		Lft. Hd. 1–10		Lft. Hd. 11–20		Lft. Hd. 21–31	
	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
1st Interval	37.2	.88	41.2	.92	42.1	.72	33.7	.75	36.5	.90	37.1	.72
2nd "	35.8	.86	39.5	.88	40.7	.62	31.9	.80	35.4	.56	36.2	.46
3rd "	34.7	.94	38.0	.78	39.4	.40	30.7	.96	34.2	.84	35.2	.42
4th "	33.7	.88	37.0	.84	38.4	.44	30.0	.92	33.2	.58	34.0	.44
5th "	33.1	.80	36.4	.80	37.8	.62	29.4	.92	32.3	.56	33.2	.42
6th "	32.6	.68	36.1	1.00	37.5	.78	28.8	1.06	31.7	.64	32.2	.44

The principal point to be noted in this table is that the practice gain is in Subject I more prominent in the earlier intervals; increase therefore is mainly one of initial efficiency. In Subject II the intervals tend to gain about equally.

The most striking feature about them is that in both subjects the initial interval invariably makes a considerable gain. In-

deed, so far as the initial efficiency is concerned, one could hardly be sure that there would have been greater gain if the practice had been continued throughout the intermission. On the other hand, it is apparent that in Subject I there is much greater susceptibility to fatigue immediately after the intermission; on the 15th and 27th days all the later intervals lose, and on the 25th day the gain of the later intervals is by no means proportionate to that of the first. Subject II on the other hand, shows a very marked gain throughout all the intervals on the 15th, 25th, and on the 27th days, in every case but one, the fifth interval for the 15th day. Only on the 15th day is any special susceptibility to fatigue indicated, though it is true that the fatigue loss is on each of the three days greater than the average for the group of ten experiments in which each belongs. Both subjects found the sensations of fatigue to be much more marked on the day after an intermission, and indeed these were in Subject I practically the only times when they appeared at all. The great initial gain after the intermissions is by no means easy of explanation. It seems rather forced to interpret it as the result of a renewed "*Neuigkeitsantrieb*," especially for Subject I. It seems to be a fairly general observation, however, that partially practiced co-ordination paths may subsequently become more firmly established during a period of rest ("learning to swim in winter and to skate in summer," etc.). The intermission gain here noted is probably an aspect of this, presumably a physiological phenomenon.

11. *The effect of warming up, as brought out by practice, on the different intervals.* In order to gain some idea of the extent of the warming-up process, it was made the subject of four special experiments, which are not included in the curves. These succeeded immediately upon the twenty-fourth day of practice, and consist each of ten series made with one hand alone. The first and third of these experiments were made with the right hand, the second and fourth with the left, the routine being otherwise the same as in the regular experiments. Inasmuch as these experiments show fairly well the behavior of each hand at a high degree of practice, and illustrate many points in it that would otherwise be impossible to bring out concretely, a right and left hand experiment for each subject is reproduced in full.

These records show immediately that in the right hand at least, the warming-up process is by no means exhausted in the first five series; on the contrary, the second five series are uniformly better than the first. The individual series improve in rate up to a certain point, and then the warming-up process is no longer sufficient to counterbalance the unrecovered fatigue from series to series, when the series begin to fall off. The

TABLE VII

Experiments of 10 series each upon the same hand throughout of Subjects I and II, after 24 days of practice.

TABLE VII

Experiments of 10 series each upon the same hand throughout of Subjects I and II, after 24 days of practice. The series followed each other at 3′ intervals.

	Subject I. (Rt. Hd.)							Subject II. (Rt. Hd.)						
	1st interval 0′–5′	2nd " 5′–10′	3rd " 10′–15′	4th " 15′–20′	5th " 20′–25′	6th " 25′–30′	Total.		1st interval 0′–5′	2nd " 5′–10′	3rd " 10′–15′	4th " 15′–20′	5th " 20′–25′	6th " 25′–30′	Total.
1st series	40	37	35	34	32	32	210	1st series	41	38	36	36	35	35	221
2nd "	38	38	36	33	33	32	210	2nd "	40	39	38	38	37	36	228
3rd "	40	39	36	35	34	33	217	3rd "	41	40	40	39	38	37	235
4th "	41	39	38	37	35	36	226	4th "	42	41	40	40	40	39	242
5th "	42	39	38	38	36	35	228	5th "	42	42	40	40	38	38	240
6th "	41	40	37	36	36	35	225	6th "	43	43	40	40	40	40	246
7th "	42	41	38	38	36	36	231	7th "	43	42	42	41	41	40	249
8th "	40	41	39	37	35	35	227	8th "	43	42	41	40	41	40	247
9th "	41	39	37	36	35	34	222	9th "	43	42	42	40	40	39	246
10th "	40	38	37	35	34	35	219	10th "	43	41	40	39	39	40	242
Av.	40·5	39·1	37·1	35·9	34·6	34·3	**221.5**	Av.	42·1	41·0	39·9	39·3	38·9	38·4	**239.6**

TABLE VII. (Cont.)

	Subject I. (Lft. Hd.) 1st interval 0″–5″	2nd " 5″–10″	3rd " 10″–15″	4th " 15″–20″	5th " 20″–25″	6th " 25″–30″	Total.	Subject II. (Lft. Hd.) 1st interval 0″–5″	2nd " 5″–10″	3rd " 10″–15″	4th " 15″–20″	5th " 20″–25″	6th " 25″–30″	Total
1st series	39	35	33	33	30	31	201	1st series	36	36	34	32	33	32	203
2nd "	39	35	34	32	32	32	204	2nd "	35	36	34	33	33	33	204
3rd "	40	36	35	34	33	32	210	3rd "	38	37	37	35	35	34	216
4th "	38	37	35	35	33	33	211	4th "	38	37	36	35	34	33	213
5th "	40	38	36	35	32	34	215	5th "	39	37	36	35	34	33	214
6th "	39	38	35	35	33	32	212	6th "	38	38	36	34	34	32	212
7th "	38	36	34	33	33	31	205	7th "	37	37	35	34	34	31	208
8th "	38	37	35	33	33	32	208	8th "	37	37	36	35	33	33	211
9th "	35	35	32	33	32	31	198	9th "	37	37	34	33	32	31	204
10th "	36	35	34	33	33	31	202	10th "	37	37	35	35	33	31	208
Av.	38.2	36.2	34.3	33.6	32.4	31.9	**206.6**	Av.	37.2	36.9	35.3	34.1	33.5	32.3	**209.3**

maximum in the right hand is never reached until the seventh or eighth series. In the left, on the other hand, the maximum is reached more quickly, and we see more of the falling off process; this much more clearly in Subject I. The second five series with the right hand are distinctly better than the first five, though in the left hand the reverse is true in the series quoted.

In further examining the records, especially those of the right hand, in which the phenomenon is more clear cut, we see again the point already brought out regarding the more precise character of this warming up gain. It is a gain that affects all the intervals somewhat, but the later rather more than the earlier; *i. e.* the gain comes mainly through an increased immunity to fatigue. Thus we see that while the initial performance of Subject I's right hand increases only from *40* to *42*, the final interval increases from *32* to *36*. In the left hand the initial gain is practically *nil;* that of the final interval from *31* to *34*. The initial interval of Subject II's right hand gains from *41* to *43*, the final interval from *35* to *40*. His left hand, as has been noted, is anomalous with respect to the warming up phenomenon. Here we find the initial intervals gaining, while the final ones tend to lose. This loss is accompanied by considerable sensation of fatigue.

This warming up increase in the later intervals probably persists a considerable time; longer at least than the fatigue that we see gradually lowering the efficiency of the later series. This appeared in a group of subsequent experiments on the right hand of Subject I in which two records of five series each were made within one hour 45 minutes of each other. Table VIII, p. 468, will illustrate this point:

The final intervals in the 3:45 record warm up from **31** to **35**, with a considerable increase also in the initial interval; those of the 5:30 record begin at **34** and warm up to **37**, with negligible increase in the initial interval. Sometimes, also, the final interval does not warm up at all in the 5:30 record; but the essential point is that the final interval in the 5:30 record always begins considerably ahead of that in the 3:45 record. It should be mentioned that series taken at 8:45 A. M., show in all respects the same characteristics as those of 3:45 P. M. on the same day.

12. *An "index of fatigue."* It is of course impossible to obtain a complete view of the fatigue phenomena in any experiment in the absence of the entire curve. But while the record does give us a curve of this sort, it is quite impracticable to evaluate all its factors, and as has been said, we

TABLE VIII
Subject I, Right hand
3:45 P. M. 5:30 P. M.

	1st interval 0″–5″	2nd interval 5″–10″	3rd interval 10″–15″	4th interval 15″–20″	5th interval 20″–25″	6th interval 25″–30″	Total.
1st Series	40	37	36	33	33	31	210
2nd "	38	37	36	35	34	32	212
3rd "	42	39	37	37	35	34	224
4th "	42	40	39	36	36	34	227
5th "	43	40	39	37	37	35	231
Av.	41.0	38.6	37.4	35.6	35.0	33.2	**220.8**
	1st interval 0″–5″	2nd interval 5″–10″	3rd interval 10″–15″	4th interval 15″–20″	5th interval 20″–25″	6th interval 25″–30″	Total.
1st Series	42	40	37	36	35	34	224
2nd "	39	38	36	36	36	34	219
3rd "	42	40	37	37	35	36	227
4th "	42	42	39	37	36	36	232
5th "	43	40	38	38	37	37	233
Av.	41.6	40.0	37.4	36.8	35.8	35.4	**227.0**

consider merely the amount done in the successive 5″ intervals. This together with the inspection of the record, will give a very fair idea of all but the finest fluctuations. And yet when we consider the number of individual curves with which we have to deal it will readily be seen that it is impossible to state the phenomena even at this length in their entirety. All things

taken into account, it is probably best that we should use some single figure as the expression of fatigability. This figure, which is here used as the "index of fatigue" and which will subsequently be denoted by *f*, is calculated by taking the average number of taps executed in the 2d, 3d, 4th, 5th and 6th intervals, and dividing it by the number of taps executed in the first interval. Thus, a curve may run as the first one in the type experiment on p. (438), *41, 37, 35, 34, 34, 32*. The number of taps in the first interval being *41* and the average number in the remaining five intervals being 34.4, *f* equals $\frac{34.4}{41.0}$ or .85.

This figure gives us the gross amount of decrease in rate during a certain period, though, of course no idea as to the form or speed with which the decrease sets in. Its main arithmetical source of error is that the number of taps made in the first five seconds is rather coarse on account of being given in the form of an integer, its probable error being about half a tap each way. *The higher the f the greater the immunity to fatigue; the lower the f the greater the susceptibility.*

13. *Correlation of the fatigue phenomena in the different hands.* All statements of individual differences, correlations, etc., in fatigability, are made upon the basis of this *f*. It is possible in a measure to test the validity of the *f* by comparing the results with the right and left hands. The results of the ten subjects show a slight tendency for the individual who is fatigable with his right hand to be also fatigable with his left, and for the day of greater fatigability with one hand to correspond to the day of greater fatigability with the other.

It has already appeared, however, in other aspects of the results, how much the delicacy and responsiveness of the test is increased by practice. The results of the practised subjects seem to indicate a greater correspondence between the fatigability of right and left hand than is found in the ten normal subjects, though even here the conclusion depends somewhat upon the method by which we treat the data. Taking the average *f* for the five series of each day as most representative of the *f* for that day, we have for the thirty experiments thirty *f*'s for each hand. Arranging the thirty *f*'s for the right hand in order of size, and comparing this order with that of the left hand, we find between them 37% of displacements for Subject I, 43% for Subject II.[1] This is again but

[1]With reference to this correlation method *cf.* Ruediger, The Field of Distinct Vision, *Arch of Psych.* 5, pp. 37-8; Wells, A Statistical Study of Literary Merit, *Arch of Psych.* 7, p. 23.

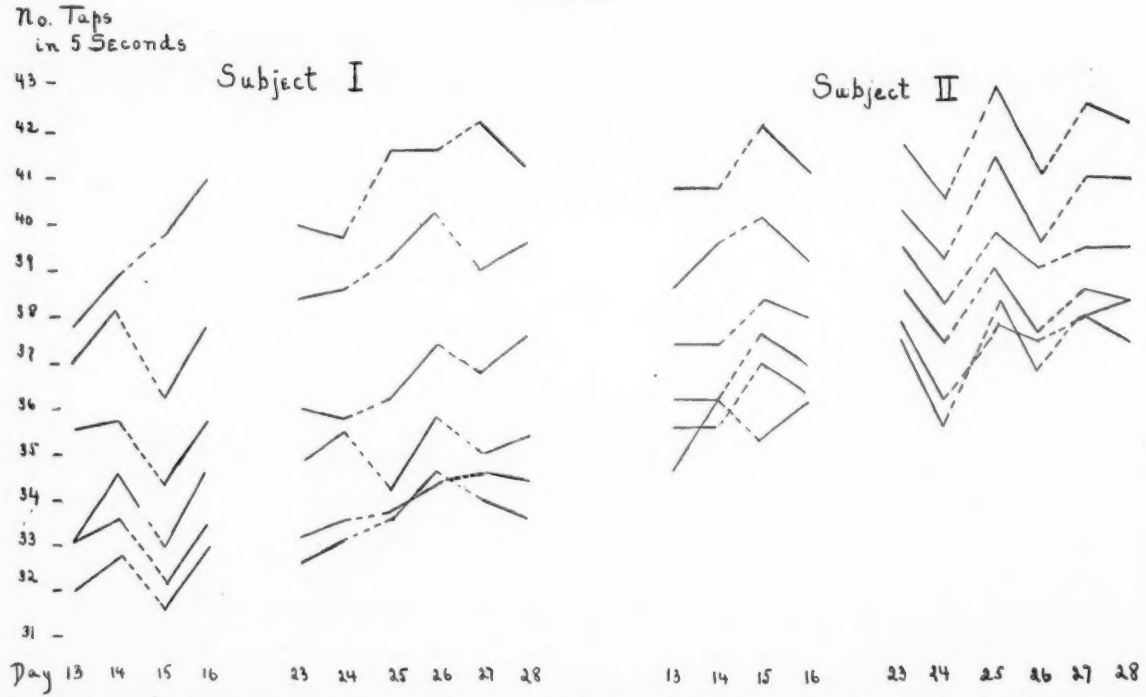
a small positive correlation. We may also observe whether the right and left hands tend to increase or decrease together from day to day; this seems to the writer perhaps the most logical way of treating data of this precise nature. We may plot curves of the f's of the right and left hands for different days, and superpose them. This gives us the figure in Plate IV. In examining these curves, we may note that with respect to ascent or descent the left hand follows the right with considerably more frequency than is provided for by chance. The chance correspondence would be 14.5, 50% of the cases; it actually occurs in 22, 76% of the cases for Subject I, and 21.5, 74% of the cases for Subject II, as can be seen by the study of the curves. It may be noted that the fewer negative and zero cases are more likely to be extreme than the more numerous positive ones, *cf.* days 15, 24 and 28 for Subject I, and 7 and 8 for Subject II. This would again suggest that the negative relationships were the product, not of chance variation, but of the intercurrence of uncontrollable conditions affecting one hand especially. To the extent to which positive correlation between right and left hand exists, the measure is one of a general condition; for the rest it refers only to the specific neuro-muscular mechanism involved in the movements of either hand.

In the face of these indisputable cases of the right hand showing one extreme, the left the other extreme of fatigability, and this in a test of such high mathematical precision as the present, it is plain that we must either postulate a considerable influence of the work of one hand upon that of the other or else largely give up the measure as an index of a general fatigability. In a few instances, especially in the later practice of Subject I, the former possibility would seem justified, but there are still marked cases as that of the 8th day in Subject II which cannot be explained in this way. While, then, the two hands do seem to have a tendency to correlate positively, each hand seems also to be subject to so many effects specific to itself—irrelevancies, as Spearman would call them—as largely to limit the value of the single measure as a general measure. And we cannot be sure that the fatigue phenomena of different functions, as the tapping test, the ergograph and the addition test, would exhibit a traceable correlation, at least in normal individuals.

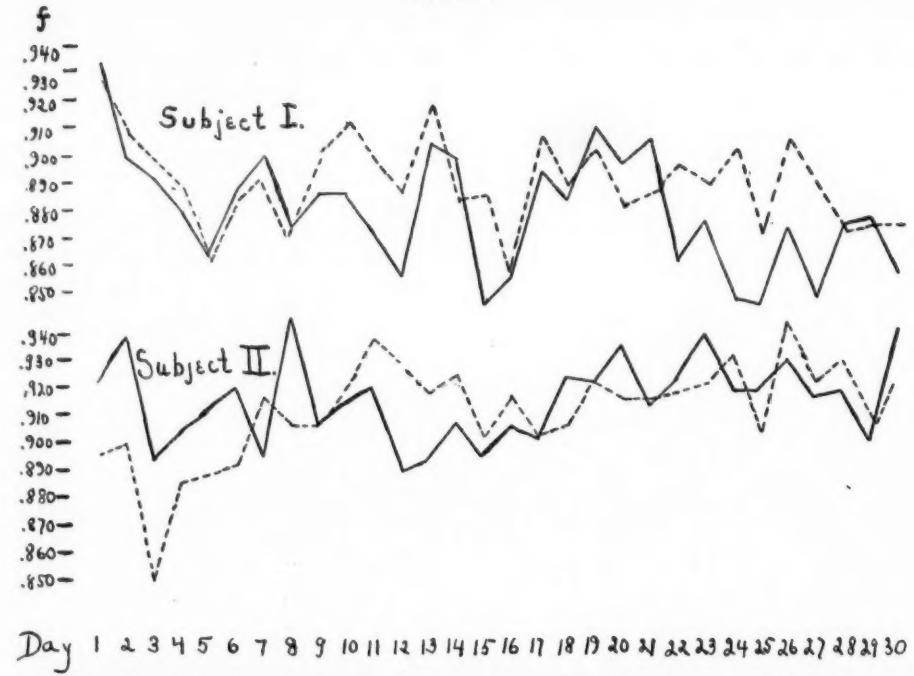
14. *The relative fatigability of right and left hands.* There seems to be no regularity in the relative fatigability of right and left hands among different individuals; in some the preferred, in others the unpreferred hand shows the greater immunity to fatigue. More frequently, however, we find that the preferred hand has the greater immunity to fatigue, and

PLATE III

No. Taps



Records of the right hand on the days immediately preceding and following intermissions, which are given in dotted lines. There is an unrecorded practise of 20 series during the intermission before the 25th day (unrecorded in the curves), succeeding immediately upon the 24th day. (*Cf.* p. 464.)



The course of the *f* during practise. The continuous line gives the *f* of the right hand, the dotted line the *f* of the left hand, in both subjects. These curves show the general effect of practise on fatigability, as well as the relationship of the two hands.

this is the relationship which obtains in the averages for the ten normal subjects. The relationships in the two practiced subjects can be best seen by again referring to Plate IV. In Subject I the fatigability of the right and left hands is about equal at first, in Subject II the left hand is much more susceptible than the right; but it will be seen that the effect of practice is in both subjects to immunize the left hand to fatigue more than it immunizes the right.[1] In Subject II they end about equal. A possible interpretation of this fact is as follows: Practice diminishes fatigue sensations, and since the left hand is more subject to fatigue sensations than the right, it probably diminishes those of the left more than it does those of the right. If, then, fatigue sensations have an inhibiting effect on the tapping rate, the result is entirely what we should expect. But it must be remembered that in this experiment the relation between fatigue sensation and fatigue of performance is only an indirect one. In the ergograph it is the muscle which does the work, and the muscle which shows the fatigue sensations; but in the tapping test there is every reason to believe that the muscles would, during any fatigue conditions that are reached in the present experiments, execute an indefinite number of taps if only they received the innervations fast enough. The objective fatigue phenomena which we note in the test are in all probability either a fatigue phenomenon in the refractory phase or a lowered efficiency of co-ordination, equally a product of altered synaptic conditions; the sensations of fatigue on the other hand, may with equal assurance be ascribed to tissue changes within the muscles that take place as a result of their continued effort. In this test, therefore, the fatigue sensations are absolutely no indication of the actual fatigue conditions, and any traceable correspondence between fatigue sensation and fatigue of performance must be regarded as almost wholly a product of reflex inhibition. In this way we can perhaps judge something of the relative responsiveness of the two subjects to sensations of fatigue. As noted, sensations of fatigue are in both subjects especially prominent the day after an intermission, but Subject II shows no special objective susceptibility on such days, Subject I a great deal. By itself, this result could be taken to mean that Subject I was more responsive to sensations of muscular fatigue than Subject II. But, on the other hand, Subject I had practically no sensations of

[1]The question is actually more complicated than appears here, involving in Subject I certain questions of the relation of warming up, practice and fatigability; but the matter is rather too complex in proportion to its importance to detail here, further analysis seeming to justify the same result as appears superficially.

fatigue except on such days, and naturally responded to them more when he perceived them than when he did not; while II was considerably subject to them throughout the experiments, especially in the left hand. Then, too, there is no other way of gauging the relative intensity of the fatigue sensations in the two subjects, or the extent of the physiological processes which bring them about. In this connection it must also be noted that I while considerably less subject to fatigue sensations than II is distinctly more subject to actual fatigue losses than II. The figures, as well as those for the 10 subjects, are shown in the following table:

TABLE IX

Relative Fatigability of Right and Left Hands in the Different Subjects

	10 Normal Subjects	Subject I			Subject II		
		Days 1–10	11–20	20–30	1–10	11–20	21–30
Rt. hd.	.912	.890	.882	.870	.915	.912	.922
Lft. hd.	.897	.895	.892	.884	.896	.918	.924

Taking as the unit the average f in each experiment, the m. v.'s of the above quoted averages are for the normal subjects .038 and .030 respectively; for the practiced subjects they range between one-fourth and two-thirds as much, being considerably smaller for Subject II.

15. *The correlation of fatigability and initial rate.* A further question presents itself in the relation of fatigability to initial rate. Each individual has a normal initial efficiency and susceptibility to fatigue, and it is the relationships of the variations of the individuals about these norms that we ought to consider. We may first give the relationships as indicated in the records made by the same individual, but on different days. In the two experiments on each of the ten subjects the day of greater initial efficiency corresponded to the day of a greater f in but 5% of the cases with the right hand, and in 35% of the cases with the left hand. In the practiced subjects, only the records for the first ten days are considered. In Subject I the correspondence of initial rate and f is 0% plus signs for the right hand, and 15% plus signs for the left; in Subject II 20% plus signs for the right hand and 45% plus signs for the left.

In examining now how the relationship subsists between the different series executed by the same subject on the same

day, we find that the negative relationship is here more clear cut than previously. We should indeed expect this, because this is the case in which the data to be compared are obtained under more closely corresponding conditions. We find that the series with the best initial rate of a single record tends also to be the most fatigable series in that record. Perhaps the matter may be more clearly brought out by the following (rather extreme) example, which is from the record of subject E.'s right hand in his second experiment:

TABLE X

No. taps in 1st Interval

	Initial rate.	*f*
1st Series	41	·77
2nd "	36	.87
3rd "	35	·93
4th "	42	·79
5th "	41	.81

It is quite obvious that the 1st, 4th, and 5th series, which have a high initial rate are also in a class by themselves in great susceptibility to fatigue, as opposed to the 2d and 3d series, which have a low initial rate, and show much less fatigue. Calculating the per cent. of like signs relationship for all the records, we obtain an average for the ten subjects of 20% plus signs for the right hand, and 21% for the left; in the practiced subjects, I gives 15% plus signs for the right and 25% for the left, II gives 32% for the right and 20% for the left. This last is the only instance in which the right hand does not give the more pronounced correlation.

We thus observe a general tendency to negative correlation between initial rate and *f*, thus of course a positive one between initial rate and *susceptibility* to fatigue. This is what we should ordinarily expect; "he who runs fast, will not run long."

16. *The effect of practice on fatigability.* The general effect of practice on the *f* have already been observed in Plate IV. In Subject I practice appeared to increase susceptibility; in Subject II there was rather increased immunity. As given in terms of *f*, the results are also seen in the gross by referring

to Table IX. The way in which practice affects fatigue in the different series affords, however, an additional point of some interest. These figures, for the three groups of ten experiments with each hand, are given in the following table:

TABLE XI

Practice and Fatigability

Average f for each series in two Groups of ten experiments

Subject I

Rt. Hd.

Days....1–10			11–20		21–30	
	Av.	M. V.	Av.	M. V.	Av.	M. V.
1st Series	.884	.022	.873	.025	.861	.019
2nd "	.910	.016	.886	.024	.865	.017
3rd "	.884	.035	.887	.025	.866	.016
4th "	.881	.015	.882	.026	.875	.027
5th "	.893	.009	.883	.025	.879	.017
Av.	.890		.882		.870	

Lft. Hd.

1st Series	.893	.019	.868	.018	.865	.019
2nd "	.912	.018	.909	.023	.890	.014
3rd "	.895	.027	.890	.018	.889	.017
4th "	.895	.025	.900	.029	.893	.024
5th "	.880	.032	.889	.018	.885	.017
Av.	.895		.892		.884	

TABLE XI. (Cont.)

Subject II

Rt. Hd.

1st Series	.902	.026	.890	.022	.896	.014
2nd "	.917	.015	.921	.018	.928	.008
3rd "	.915	.021	.920	.010	.924	.013
4th "	.923	.022	.907	.023	.930	.019
5th "	.917	.037	.911	.019	.934	.014
Av.	.915		.912		.922	

Lft. Hd.

1st Series	.892	.026	.904	.012	.910	.012
2nd "	.911	.017	.938	.022	.941	.019
3rd "	.887	.030	.916	.016	.935	.026
4th "	.889	.019	.920	.012	.916	.022
5th "	.901	.017	.909	.021	.914	.015
Av.	.896		.918		.924	

The general tendency of these tables, except always in the left hand of Subject II is that practice establishes throughout an immunity to fatigue that is progressive through the five series. We saw this illustrated in detail in the records of 10 series of one hand above printed in full (Table VII), and we can observe here how this relationship is brought out by practice. The *f*'s uniformly become larger as the later series are reached, and in later practice this tendency is much more marked than at the beginning. It is of course, another phase of the warming up process. Another point is the very low susceptibility to fatigue that is throughout prominent in the second series. By referring to Table V we see that this is also associated in the left hand with a relatively low gross rate,

though not so much as in the right. The reason for this is a rather interesting one. The *f*, as has been said, is calculated from the initial interval. Now it happens that in the second series, the initial interval is always abnormally slow; always a tap or two slower than the first, and from three to five taps slower than the later series. On the other hand, the warming up process in the later intervals is strikingly in evidence in the second series, and it is this that beside raising the gross rate of the series makes it show immunity to fatigue. This point is also very strikingly shown in Table VII. As may be seen, the uniform tendency in all four records is for the first interval of the second series to be as small or smaller than the first interval of the first series, while the second interval of the second series is as great or greater than the second interval of the first series. The figures are reproduced in Table XII, p. 479.

By comparing the performances during the first two intervals with the total, one can easily see how much more the second series resists fatigue than the first, even when, as in the left hand of Subject I, this resistance is not evident so early as the second interval. Why the first interval alone in the second series should be slower than that in the first series, and the remaining intervals uniformly faster, is difficult to say, but of the general tendency there can be no doubt; it is present throughout the thirty experiments on each practiced subject, as well as quite generally in the ten unpracticed subjects. It would seem as though the warming up affected the later intervals first, and only subsequently extended its effect to the initial one.

On account of the influence of practice in establishing this warming up process, it would seem fairer to judge of the specific effect of practice on fatigability on the basis of the first series only in each record, because these have no warming up series behind them. Referring to Table XI it is evident that the immunity to fatigue as given in *f* tends with practice to decrease more, or to increase less, in the first series than in any of its followers. Indeed, the 2nd series in the right hand of Subject I, and the 5th series in the left hand of Subject II are the only exceptions to this generalization. It would seem therefore that the specific effect of practice on fatigability is in the nature of an increased susceptibility rather than an increased immunity. The increased immunity shown in the averages of Plate IV and Table IX is largely a product of the increased immunity of the later "warmed up" series. *The true practice gain is one mainly in the initial efficiency of performance, as distinguished from the warming up gain, which shows itself chiefly in continued efficiency of performance.*

It is interesting to compare the effect of practice with that

TABLE XII

	Subj. I, Rt. Hd.		Total No. Taps in Series	Subj. I, Lft. Hd.		Total No. Taps in Series	Subj II, Rt. Hd.		Total No. Taps in Series	Subj II, Lft. Hd.		Total No. Taps in Series
	0″–5″	5″–10″		0″–5″	5″–10″		0″–5″	5″–10″		0″–5″	5″–10″	
1st Ser.	40	37	210	39	35	201	41	38	221	36	36	203
2nd Ser.	38	38	210	39	35	204	40	39	228	35	36	204

of age. Both, as may be accepted as certain, tend to increase the rate, and it increases from childhood to adolescence con-

siderably more than it does in the practice of the two adults here tested. In their effects on fatigability, however, the two are somewhat divergent. The effect of increase in age is almost certainly to increase immunity while the above mentioned specific effect of practice, *i. e.*, warming up factors excluded, seems to be to decrease it, or at least to give but very small increase. The modifications in the behavior of the tapping test with increasing age must then in a certain measure be ascribed to different factors than those operative in practice improvement.

17. *Variability.* While no average has been quoted whose m. v. has not been calculated, no great stress has been laid on variability in the preceding paragraphs, and it may therefore have a special mention here. In the present experiments the practically universal effect of fatigue on variability is in the nature of a decrease. This appears between individuals (p. 451) in the records of the practiced individuals from day to day (Table VI, pp. 462-3), and also in the records made by the same individual on the same day. There is so much interaction between warming up and practice that no conclusions regarding a specific effect of these factors on variability can be drawn. There is, however, a general tendency for the m. v.'s of the left hand to be smaller than those of the right.

This last aspect of the results is one that may be compared with certain findings of Bryan; for the most part Bryan's results are not so strictly comparable with the present on account of their averages always dealing with groups, not with individuals. However, there seems also in these findings to be a greater variability in the right hand than in the left. The individual differences in gross rate, which are here expressed in the standard deviation instead of the m. v., show on the whole a greater variability for the right hand; it will be remembered that this was also slightly the case in the present experiments. It also appeared that the year to year fluctuations in rate (among different subjects) were somewhat greater for the right than for the left hand. Although the results quoted can hardly establish the point conclusively, yet it is true that we should probably expect the hand that more nearly reflects the individual's maximum ability to vary more in its ability. In this connection it may be mentioned also that there was no significant difference in the year to year increase in the two hands; this may be compared with the result in the present study that in practice also the right and left hands tended to gain about equally.

18. *The subjective condition as related to gross rate and fatigability.* On each day of the thirty experiments, Subject I graded the general condition introspectively as *A* relatively

good, *B* above medium, *C* below medium, *D* poor. Needless to say, the grade was assigned before the experiment was begun. In all, there were thus assigned 3 *A*'s, 12 *B*'s, 14 *C*'s and 1 *D*. It was desired to see if the grade subjectively assigned tended to correlate in some degree with the gross rate, the fatigability, or other aspect of the test. So far as can be seen, the first relationship is quite chaotic. For example the best performance was made on a *C* day; the performance of the *D* day while not very good in the gross, had the highest initial rate reached yet, and followed three days after an equally poor record made on an *A* day. It would seem therefore that while the daily performances are entirely definite facts and represent such and such a physiological condition with relative precision, this condition is not one that influences the subjective estimate to any appreciable degree. The character of the warming up gain does not seem in any way related to the subjective estimate, nor, it may be mentioned, do the present experiments bear out the correlation suggested in Bolton's figures between general superiority and the presence of interserial warming up. In the index of fatigue, however, a certain relationship is indicated; but, strange to say, it is in the direction of the good days being more fatigable than the poor ones. If we consider only the last twenty days, during which the *f* is no longer subject to practice decrease, as well as the gradings being better distributed, the two remaining *A* days have an average *f* of .86, m. v. 0; the seven *B* days .875, m. v. .010; the ten *C* days .881, m. v. .019. Including the entire thirty days, the *C* average is slightly below the *B*, on account of the low susceptibility of the first few days, uniformly graded *B*; the *A*'s remain at .86. The single *D* day has the lowest *f* recorded, .84; but this is because it came on the 15th day, immediately after a two week's pause, when susceptibility is always greatly increased; it may be mentioned also that this *D* was assigned mainly on the basis of somatic sensations, which were those of marked weariness. If the result is significant, the following are two possible interpretations; the subjective estimate may have been the direct product of physiological conditions which really involved greater susceptibility to fatigue, and, owing to a good subjective condition the subject may have put forth nearer his physiological maximum of effort, and consequently fatigued more. From these considerations it follows as a corollary that the initial rate, or best performance for 5″, corresponds more closely with the subjective estimate than does the gross rate for 30″—on account of the observed relationship of high initial rate, low index of fatigue (*i. e.* high fatigability).

The principal findings of the present study may be thus presented under the various headings as given at the beginning:

1. The extremes of individual variation for 10 unpracticed subjects' rates were in initial rate approximately 2:1, in the gross rates for 30 seconds about 3:2; but it does not appear that this difference is related to general quickness, and beyond efficiency of co-ordination it is not known upon what neural condition it does depend.

2. The index of right-handedness varies between .81 and .94, and though subject to a good deal of variation in the individual, is yet a distinct point of individual difference.

3. With the 2′ 30″ rest-periods used, the right hand of unpracticed subjects tends to increase (warm up) in rate through the five successive series; but this is not so clear in the left hand.

4. After the first few seconds, the rate in the individual series progressively decreases, having, on an average, some six-sevenths as much speed during the last five seconds as in the first five.

5. The fatigue in the tapping test induced by a 30″ performance tends progressively to decrease individual differences in ability for the test.

6. For two normal individuals, the practice curve is everywhere gradual in ascent. The curve fluctuates more from day to day after a week of practice than at the beginning.

7. The left hand does not improve by practice more than the right. Practice tends to increase the m. v. of the five series of each day's performance.

8. Practice brings out the warming up phenomena (*i. e.*, the gain of later series over the earlier) to a marked extent. Next to the gross gain, this is the most important aspect of the practice effect.

9. In Subject I, practice improves the initial interval of the series more than the later; in Subject II all intervals share about equally in the practise gain.

10. Intermissions of two weeks or less have no unfavorable effect on the practice gain, beyond at first increasing fatigue sensations.

11. Warming up shows itself mainly in an increased immunity to fatigue, *i. e.*, the later intervals increase more than the earlier. Its possibilities are by no means exhausted in the five series uniformly taken; it may persist for three or four series further.

12. The ratio of the first to the average of the later intervals furnishes a convenient "index of fatigue" (f), through which to observe quantitative relationships in susceptibility and immunity to fatigue.

13. There is only slight tendency to positive correlation in the fatigability of the different hands.

14. The right hand is ordinarily more immune to fatigue than the left; but there are individual exceptions. Practice tends to affect average *f*'s of the left hand more favorably than those of the right. The fatigue sensations are not the product of any factors directly concerned in the speed of repeated movements, and any special correspondences noted between fatigue sensation and actual fatigue loss is the result of reflex inhibition. Of the two subjects, the one more liable to fatigue sensations was less liable to objective fatigue loss. Practice tended to decrease immunity to fatigue in this subject, and to increase it in the other subject.

15. Initial rate and fatigability are negatively correlated, a fast initial rate being usually accompanied by a high fatigue loss.

16. In practiced subjects, the later series of each single record are more immune to fatigue than the earlier, owing to the warming up gain, which affects the later intervals of each series more than the initial. (*Cf.* 11.)

17. Fatigue tends in all respects to decrease variability; no consistent effect on variability due specifically to warming up or practice can be traced. The m. v.'s of the right hand results tend to be larger than those for the left hand.

18. The subjective condition as estimated by an individual practiced in introspection bore no traceable relationship to the gross rate; it seemed, however, that susceptibility to fatigue was greater when the grade assigned was good than when it was poor.

THE STREAMING PHENOMENON

By C. E. FERREE, Bryn Mawr College

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INTRODUCTION

It is the purpose of this paper to supplement an article published in the *Journal*, in January, 1908,[1] (1) by publication of sketches of the streaming phenomenon, omitted from that article, and (2) by an inquiry whether this phenomenon bears any relation to the various subjective visual phenomena described by earlier investigators.

It will be remembered that the streaming phenomenon was first seen by the writer while observing the fluctuation of the negative after-image. It was confirmed at that time by a number of observers, both trained and untrained, and many have since been added to the list. A brief description is brought forward from the previous article.

"When one sits with lightly closed lids, which must be kept from quivering, before a bright diffuse light such as that of a partly clouded sky, and looks deep into the field of vision thus presented, beyond the background as usually observed, one sees about the point of regard, after the field of vision has steadied, slowly moving swirls. These swirls have the appearance of streams of granules moving in broad curves now this way, now that, seemingly without order, unless a noticeable eye-movement occurs, or is made voluntarily, when the direction of streaming changes to that of the eye-movement. The change of direction is always on a curve, the abruptness of which depends upon the vigor of the movements, much as would happen if motions of different directions and of different magnitude were compounded upon a fluid of considerable inertia. The phenomenon is extremely varied. Sometimes the central portion of the field of vision resembles the surface of a liquid about to boil, channeled this way and that by convection-currents moving at varying rates of speed. Now and again a heavy stream will sweep across this channeled surface from one direction or another, taking up the minor swirls as sharply curving tributaries, and so on, through manifold changes. Various patterns can be picked out, and a particular swirl may be traced in its devia-

[1] C. E. Ferree: *The Intermittence of Minimal Visual Sensations*, XIX, 58 ff.

tions for a time; but, as a whole, the phenomenon cannot be adequately described."

"After practice on the closed lids, the observers became able to trace the streaming on any dull or rough surface with the eyes open." Many were able to see it in this way even before they were able to distinguish it on the field of the closed lids. It "comes out with remarkable clearness with open eyes in the blackness of the dark room. The field of slightly luminous haze that there confronts one . . . . streams and whirls with convincing distinctness."

"It may also be observed under the conditions of observation of the entoptic and circulation phenomena; but just as one must look beyond the false scotomata to see the moving corpuscles and interspaces, so must one look beyond them to see the streaming."

Other conclusions must be briefly called to mind from the previous article. (1) Streaming cannot be an entoptic, circulation, or tear film phenomenon or any of the shadow phenomena, since it is seen in the darkness as well as in the light, and is, besides, radically different in behavior from these phenomena. (2) The direction and vigor of streaming are to a high degree dependent upon the direction and vigor of eye-movement. (3) Streaming has a characteristic effect upon the visual processes. For (*a*) the streams carry with them the visual quality of the background from which they come. (*b*) They tend to obliterate the negative after-image, *i. e.*, gentle streaming dims the after-image and stronger streaming blots it out. Streaming also conditions every color change in the flight of colors. And (*c*), since the negative after-image represents the obverse or recovery phase of the visual processes, streaming brings about the recovery of the adapted retina,—roughly, at least, to the extent to which it increases the fluctuation and decreases the duration of the negative after-image. (4) The streaming material can quite conceivably be identified with the metabolic substance as the vehicle of both the anabolic and catabolic processes. Metabolism requires the diffusion of lymph over the retina. The streaming of this lymph hither and thither brings to the adapted area anabolic material and carries from it catabolic waste. This catabolic waste is probably in part disintegrated visual substance, which retains for a time its power to condition visual sensation (as is shown by the fact that the streams carry with them the visual quality of the region from which they come). Thus, heavy streaming, by weakening the negative process through hastening anabolic change, and by setting up strongly the sensation of the region from which the streams come, may temporarily obscure the after-image. The effect upon the duration of the after-image is probably to be explained wholly in terms of the facilitation of the anabolic process.

Sketches of the Stream Patterns.

The sketches shown in the following cuts were selected at random from a number drawn by the observers. In cuts 1-10 are given illustrations of a few of the more noticeable and easily represented patterns for two observers, Dr. Bair and Miss Alden. In cuts 13-29 are shown the streams that caused the fluctuation in two observations on the connection between streaming and fluctuation. Figures 11-12 represent two stream-types, some form or modification of which was reported by all of the observers.

It will be understood that these sketches do not represent the phenomenon *in toto*, even for these selected cases. They are but a few patterns dissected out, as it were, from the complexity of streaming. It would be impossible to portray even a single cross section of the disturbance, unless the visual field could be fixed for that instant.

Figures 1-6 were drawn by Dr. Bair (*B*). The observation was made near the middle of a clear day in Colorado, October, 1907. The observer sat about three m. from a long window facing the south, and obtained the after-image of a strip of Milton-Bradley yellow paper, 42 by 4 cm., pasted upon a sheet of Milton-Bradley blue, 50 by 60 cm. On the field of the closed lids this stimulus gave a violet strip on a reddish yellow field, a condition especially favorable for the observation of streaming and its effect on the visual processes. This series of sketches is not continuous, representing the fluctuations of one after-image, but is sampled from the observation of several after-images. A break in the outline of the strip in the drawings represents the disappearance of that part of the after-image.

Figure 1 represents a stream which swept to the right and downwards across the after-image, and, turning upon itself sharply in an uncompleted loop, swept back to the left and upwards, blotting out all of the after-image lying between its external borders. In Figure 2 two streams, the one coming from above and the other from below, swept across the after-image from the left in two closely contiguous parabolic curves, blotting out about one-third of the after-image above and below the centre. In all such patterns, when two streams pass near each other, or when a stream turns upon itself, the region between the stream channels is also strongly agitated. This we may call the region of secondary streaming. Figure 3 represents a narrow stream which swept to the right and downwards across the after-image, and, turning, came back upon itself in a broad loop-shaped curve. Two sections of the after-image, each slightly broader than the stream, the one situated above and the other below the centre, were blotted out. In Figure 4 the stream passed across the after-image to the right and, turning broadly upon itself, passed back to the left across the image, and then sharply downwards, losing itself in a broad fan-shaped expansion. Two sections were blotted out; the one short and near the top, the other longer and very irregular in outline,

near the bottom. In figure 5 two streams from the left, the one passing to the right and upward, crossed each other in an X-shaped pattern slightly above the centre of the after-image, blotting out about one-third of its upper half. Figure 6 represents a stream which passed across the image upwards and to the right and, turning upon itself in a vertical oval, passed downward and to the left, along a path nearly parallel to its previous course, cutting out an elongated diamond-shaped section comprising about half the area of the after-image.

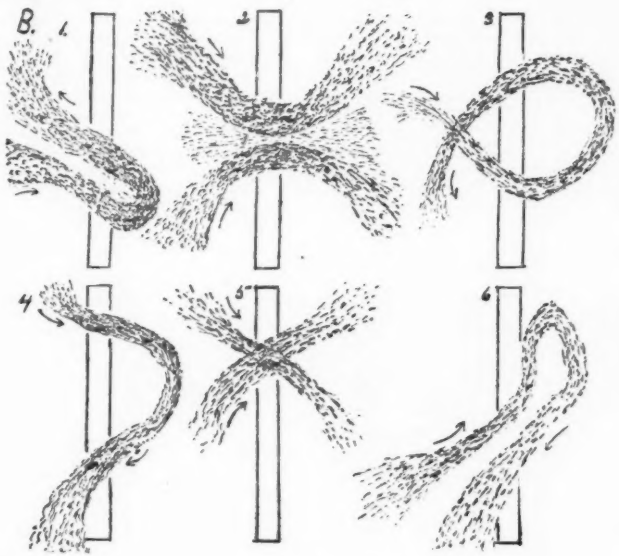

PLATE I

Showing some of the more noticeable and easily represented patterns for Observer *B*. Broken Series.

Figures 7-10 were drawn by Miss Alden (*A*). The conditions for observing 7, 8, and 10 were the same as for the previous observer; but to get the stimulus for Figure 9, the curtain was lowered over the window in front of which the observer sat, and an opening in the shape of a right triangle was cut in it. The sash was lowered and the observer looked through the opening in the curtain at the clear sky. Thus the stimulus was a very bright blue triangle on a dark background.

In Figure 7, first, a stream coming from below and to the left passed across the image, diagonally upwards and to the right. This

was followed immediately by a stream coming from above and to the left which passed diagonally downward and to the right, crossing the path of the first stream in the centre of the field of vision. Before this stream had completed its course, however, it was swept across and taken up by a third stream, moving on a parabolic curve from the right. A large section was blotted out of the central portion of the after-image. In Figure 8, the after-image was swept across, first, by a stream passing downwards and slightly to the right. This was immediately followed by a stream passing upward and slightly to the right. The two streams seemed to form the limbs of a loop, the apex of which was too far advanced into indirect vision to be perceived. Strong secondary streaming was observed to the right of the intersection of the two streams. A large section was blotted out of the centre of the after-image, extending also down the lower left edge. Figure 9 represents a pattern very similar to that of Figure 8, but drafted on broader lines. A wide stream, curving downward and slightly to the right, passed across the triangular after-image, immediately followed by a return stream moving on a similar curve upwards and slightly to the right. This figure also strongly suggested that the two streams were in reality but successive stages of one stream moving in a broad loop-shaped curve. The whole triangle was blotted out,

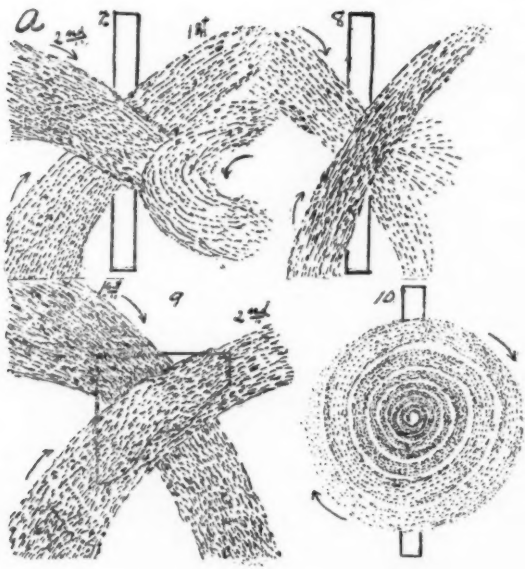

PLATE II

Showing some of the more noticeable and easily represented patterns for Observer *A*. Broken Series.

with the exception of a very small portion of each of the two legs. Figure 10 represents a pattern frequently observed. A swirl small at first begins at the centre of the field of vision and expands centrifugally. It may take in quite a large area of the field of vision before it is swept in this direction or that into a definite stream-form. Expanding as it swirls, and encroaching more and more upon the after-image, this pattern affords a striking and easily observed example of the connection between streaming and the fluctuation of the negative after-image.

Figures 11 and 12 are represented in Plate III.

Figure 12 shows a peculiar pattern, frequently present in some form or other. The stream begins at the periphery in a fan-shaped expansion and moves in a broad curve towards the centre of the field of vision, where it turns sharply upon itself and forms a spiral swirl. At first the movement is slow, but increases rapidly as the stream narrows. Frequently, during the swirling, the movement will reverse and the spiral unwind, sending off a stream towards the periphery which in turn may curve broadly upon itself and return to the centre, thus forming a second swirl similar to the first, and so on through a

PLATE III

Showing two stream types, some form of which was reported by all of the observers.

number of repetitions. The actual pattern is but inadequately shown in the diagram. Figure 11 shows a very frequent pattern. Two streams moving in opposite directions on a path of slight curvature sweep in towards the centre, and when about to collide turn and complete their paths on parabolic curves. At the apex of each curve the movement is rapid. Strong secondary streaming takes place between the curves, tangent to them at their point of contact, and having the same direction as the primary streaming at this point of contact. In the open this secondary stream is broad and slow, but in the narrow space between the primary streams it is whirled into swift motion. It behaves as if it were drawn in from the surrounding field by the rapid swirl of the primary streams, and were cast out, to lose itself in it again, when the granules of the primary stream enter upon the second part of their course.

Figures 13-21, Plates IV and V, drawn by *A*, represent the streams causing the fluctuation of the after-image of a strip of Milton-Bradley standard yellow paper 42 by 4 cm., from its appearance until its final disappearance. The time of stimulation was 40 seconds, and the distance of the observer from the stimulus was 1 meter. The observation was made in Colorado in October, the observer facing an open window with southern exposure, as was previously described. Only those streams were sketched which caused the after-image to disappear as a whole or in parts.

No streaming was noticeable at first. The after-image was very bright. Gradually a gentle streaming began which dimmed the after-image. Figure 13: a stream moving on a path of slight curvature, downwards and towards the left, swept across the lower part of the after-image. This was immediately followed by a broader stream, of slightly greater curvature, moving downwards and towards the right. The paths of the streams crossed a little to the right of the after-image. The lower third of the image was blotted out. Figure 14: a stream curved downwards and to the left, blotting out about a third of the after-image at the top. Figure 15: a broad, heavy stream, sweeping down from above and to the left, carried the background over the entire image, blotting it out completely. At this point the streaming grew more intensive, the streams became broader and fluctuation became more frequent. Figure 16: a stream sweeping downwards and towards the left blotted out the lower half of the after-image. Figure 17: a broad stream moving almost on the diagonal downwards and towards the left, swept out the whole after-image. Figure 18: a second broad stream, moving downwards and towards the left, but more inclined towards the vertical than the preceding one, passed across the after-image. The streaming was gentle at first, only dimming the after-image, but gaining in intensity soon swept it entirely out. Figure 19: a stream moving towards the right and downwards blotted out the top of the after-image. Before this had passed entirely off the image, a second stream curved downwards and to the left, crossing the first stream to the right of the image, and with it sweeping out the upper two-thirds of the after-image. Figure 20: a broad stream, following the diagonal, swept downwards and to the left across the image, blotting it out completely. Figure 21: a broad stream covering nearly all of the after-image, swept downwards and to the right. Before this had entirely cleared away, a slightly narrower stream came down from

above and the right, crossing the first in an X-shaped pattern. Both streams together blotted out all but the very edge of the bottom and a small portion of the top. From this time on the streaming became still more intensive, and the fluctuation still more frequent. The image would scarcely clear from a previous stream before another swept it out again. The fluctuations were too rapid to fix in mind for sketching. The after-image became dimmer at each reappearance and soon vanished. In all of the above cases the after-image was seen to reappear from behind the stream, as this cleared away, the clearing generally beginning in the direction from which the stream came.

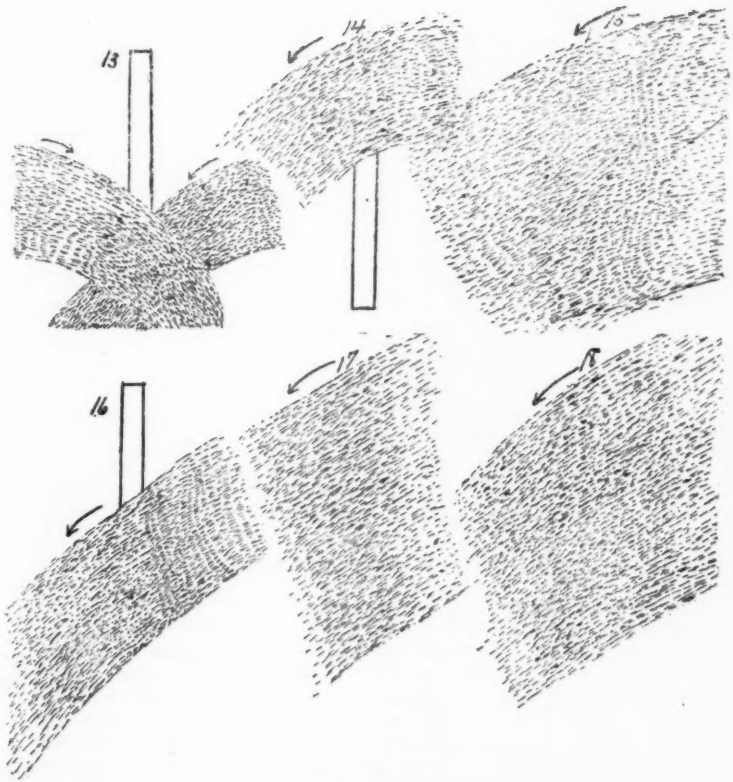

PLATE IV

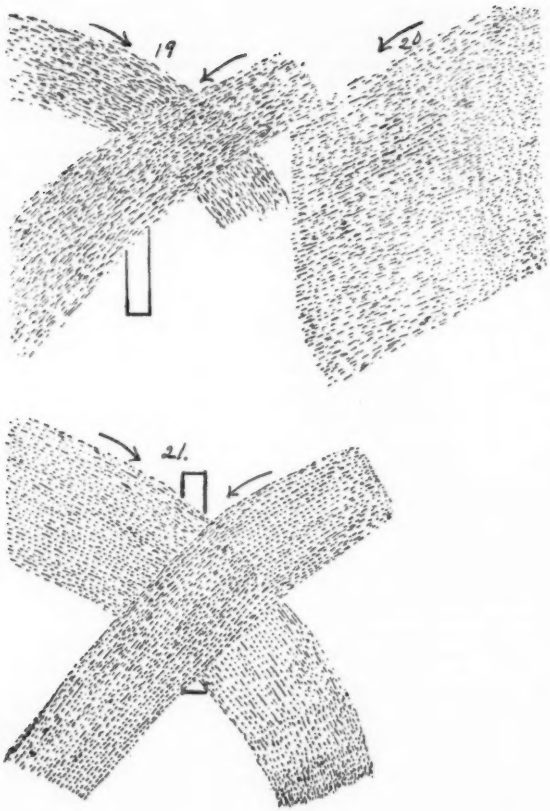

PLATE V

Showing the streams which caused the fluctuation of a given after-image for Observer *A*. Time of stimulation : 40 sec.

Figures 22-29 illustrate still further the connection between streaming and the fluctuation of the negative after-image. The stimulus and experimental conditions were the same in this case as in the former, with the exception that the time of stimulation was only 30 seconds. In a comparison of the two series, a difference will be noticed in the character of the streaming. In the first series the streams were of the nature of

bold, vigorous sweeps of little curvature, such as are caused by eye-movements of considerable range, while in this series they show a more pronounced curvature and are in general more complex in pattern. This difference may be accounted for in part by the difference in the time of stimulation (which permitted the observer a better control of fixation on projection of the after-image), but is probably due largely to the individual difference in steadiness of fixation for the two observers, as shown by their eye-movement records.

There was first a gentle streaming over the whole area of the after-image. A light stream (Figure 22) swept downwards and towards the right, almost, but not entirely, blotting out the after-image. Figure 23: a swirl moving counter-clockwise and coming from above and to the right, was carried across the upper half and centre of the after-image, causing a long disappearance. This is a peculiar and not infrequent form of streaming. Two independent motions are impressed upon the same particles. The granules revolve about a common centre and at the same time are carried forward in a linear path, much as are the atmospheric particles in the vortex of a storm cloud. At times the vortex motion is not so prominent, the phenomenon presenting the appearance of finely powdered snow driven before a brisk wind. Figure 24: two streams, the one moving from the left, the other from the right, joined and passed upwards, blotting out the after-image along its entire length. Figure 25: a stream moving obliquely down and to the left, swept out the lower part of the after-image. Almost immediately another, apparently a continuation of the first, swept up and to the right, carrying out the centre and upper half. Figure 26: a swirl moving counter-clockwise cut off the top of the after-image. Figure 27: a stream moving across the centre from the left, when considerably beyond the after-image, divided and swept back on itself in two broad curves, carrying out the centre, top, and bottom of the image. Figure 28: a stream moving on a very gradual curve to the right, downwards, and to the left, blotted out all but the right edge of the lower half of the after-image. Figure 29: a heavy stream moving across the centre from the right divided and swept back on itself obliquely towards top and bottom, carrying out the whole after-image. From this time on, the visual field was in more or less general commotion. The fluctuation consisted of faint, short appearances, usually of only a part of the after-image at a time, and of long disappearances. The image soon vanished.

The Circulation Phenomenon

In the previous article, the writer showed that the streaming phenomenon cannot be identified with any of the known entoptic or circulatory phenomena of the retina. It devolves upon him here to show that it cannot be identified with any other of the subjective visual phenomena hitherto described, or with any unclassified observations that have been reported in the description of these phenomena or of the circulation phenomenon. To this end it will be necessary to take into account the published accounts of the circulation phenomenon,

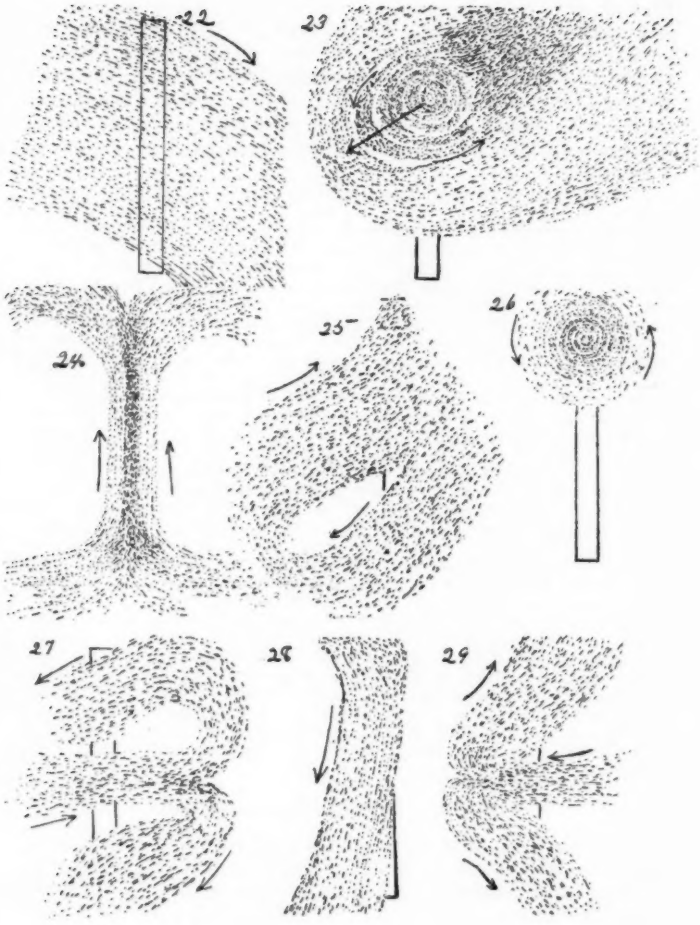

Plate VI

Showing the streams that caused the fluctuation when the after-image was projected with a steadier fixation than obtained for *A* in Plates IV, V.

and of that indefinite group of phenomena called variously *Lichtchaos*, *Lichtstaub*, *wandelnde Nebelstreifen*, etc.

The first reference to the circulation phenomenon appears to have been made by Sauvages.[1] It occurs, however, in his chapter on vertigo, and can scarcely be considered an observation of the normal circulation of the blood. He says: "Si oculis parietem album proximum respicientibus, lucem retro accedentem, solarem non tamen directam sed reflexam recipiat paries, observator videt in muro reticulum obscurum, mox evanescentem."

Darwin, Steinbuch, Purkinje, Ruete, Meissner, Johannes Müller, Vierordt, Rood, Rogers, Aubert, Helmholtz, Odgen and others (see footnote 2, p. 500), have also described the circulation phenomenon; but for our purpose Vierordt's report alone will repay close investigation. The others will be briefly considered merely for the sake of historical continuity.

The first report of the normal flow of the blood through the retinal capillaries was made by Darwin,[2] who states that he could see the moving corpuscles when gazing at the sky or some other bright field, after holding his breath or rubbing his eyes. A few years later Steinbuch,[3] who believed that he was able to distinguish the outline of the vessels as well as the movement of the corpuscles. He found that observation is facilitated by pressure on the eye-ball, when "Reihen von fliessenden Kügelchen" are plainly seen. Purkinje[4] reports that on fixating an extended, well-illuminated surface, bright points are seen in the field of vision, which traverse definite paths at an uniform rate of speed, and appear and disappear at irregular intervals.

Johannes Müller[5] says that a general impression of the movement of the blood may be obtained in many ways; especially if one regards a bright but not shining surface, as the sky, or stares for some time fixedly at the surface of snow or white paper. The phenomenon consists of a confused jumble of intermingling, darting points, or of a vague irregular movement as of mist or smoke, and is so indefinite that not even the direction of movement can be determined.

Ruete,[6] looking at the sky through blue glass, saw many

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[1] Nosol. method., Amsterd., 1763. Tome 3, 242.

[2] R. W. Darwin: New Experiments on the Ocular Spectra of Light and Colors, Philosoph. Transact., LXXVI (2), 1786, 313. See also G. J. Burch, Nature, LIII, 558.

[3] Harless, *Jahrbuch der deutschen Medicin und Chirurgie*, 1813, III., 2, 270.

[4] *Beobachtungen und Versuche zur Physiologie der Sinne I*, 1823, 127.

[5] *Physiologie des Menschen*, 1837, II, 390.

[6] *Bildliche Darstellung der Krankheiten des menschlichen Auges*, 1854, 56.

streams wandering hither and thither, each stream consisting of a single row of alternatingly light and dark points. The points moved in circular paths, convexly curved and frequently intersecting. As pictured by him, the phenomenon presents an appearance very like a hive of bees in the act of swarming. Ruete's description of the circulation phenomenon differs from that given by any other observer ;[1] but it nevertheless no more resembles a description of the streaming phenomenon than do the others. The sole point of resemblance to the ordinary accounts of the circulation phenomenon is the mention of "light and dark points" which are seen "in narrow and unchanging paths of motion." This feature alone, however, would be sufficient to differentiate Ruete's observation either from the streaming phenomenon or from the *Lichtchaos*, *Lichtstaub*, etc. Ruete also mentions that the phenomenon is emphasized by the retinal congestion produced as one suddenly rises from a stooping position.

G. Meissner [2] describes two methods by means of which he was able to observe the retinal circulation. When he looked through a small opening at the bright surface presented by the globe of a lamp, with the eye accommodated for a very short distance, the field of vision suddenly darkened and light flecks of irregular form appeared in great numbers. These flecks were very close together, but distinct in outline from the beginning. Motion was gradually set up among them in the most diverse directions, along paths in some places wide, in others narrow, here separating and there reuniting, with the appearance of vessels in which blood corpuscles were rapidly coursing. In the second method, the one eye was closed and the other looked through a lens at the globe of a lamp placed at such a distance as not to give an image, but an intensely bright, uniformly illuminated field. This, when stared at awhile, became dark and slightly tinged with green ("wahrscheinlich in Folge einer Ueberreizung"). In the field of vision thus formed the circulation was plainly visible.

Vierordt [3] distinguishes four stages in the observation of the circulation phenomenon. His method and observation may be described as follows. The left eye was closed and a sheet of milk-glass, uniformly illuminated and placed at a distance of 100-130 mm., was stared at with the right. The fingers, slightly spread apart, were moved rapidly to and fro (120

[1] Vierordt (*Archiv für physiologische Heilkunde*, 1856, 256), commenting upon this, says: "Ich bin nicht im Stande die Gestalten meiner Blutströmchen in der Ruete'schen Figur auch nur im entferntesten wieder zu erkennen."

[2] *Beiträge zur Physiologie des Sehorganes*, 1854, 84.

[3] *Archiv für physiologische Heilkunde*, 1856, 258.

times per minute or thereabouts) as near as possible to the eyes. After the lapse of a few seconds, never more than a minute, a confused general movement was set up on the white milk-glass surface. This soon resolved itself into numerous light points moving indefinitely hither and thither (first stage), and later into a streaming of the points in definite and fixed directions, but not in channels or paths that were themselves distinguishable (second stage). In a short time, on account of fatigue of the retina, the bright white spaces between the streams became darker. The stream paths themselves, becoming slightly darker, were thus rendered plainly visible. A peculiar state of fluctuation was now induced. Sometimes the visual field would become white again, in which case the stream paths became indistinct (second stage). Then the visual field would again become darker, *i. e.*, become a grayish green, whereby the larger vessels would be made apparent in a brownish color and clearly outlined (third stage). The smaller vessels, however, were still unrecognizable, and the observer received only the general impression of movement, without being able to distinguish the individual corpuscles. Between these two extremes lay an intermitting middle state (fourth stage). The long narrow spaces between the vessels became uniformly light, and frequently also the individual corpuscles could be sharply distinguished as faintly yellowish points. Vierordt says that this fourth stage is that best suited to the observation of the phenomenon, which presents a very surprising and striking appearance, often lasting from 2 to 4 minutes. For observation at this stage the finger movements may be slowed, but cannot be dispensed with entirely.

A difference of opinion seems to exist with regard to Vierordt's observation. Vierordt himself considers it an observation of the circulation phenomenon, and discusses it with that reference throughout. Helmholtz,[1] however, discusses it under the heading *Lichtschattenfigur*, and other systematists, doubtless following his lead, also treat it as a phenomenon of intermittent illumination. Helmholtz, who produces his alternation of white and black sensations by staring at a rotating disk made up of white and black sectors, instead of moving the fingers before the eyes, as Vierordt did, describes the phenomenon as a formless streaming, the direction of which may change as it proceeds, and attributes it to a circulation of lymph rather than to the circulation of the blood. It is chiefly on account of this conflict of opinion, and not by reason of any similarity between this and the streaming phenomenon, that Vierordt's observation and the circulation

[1]Physiol. Optik, 1896, 533.

literature in general have been considered here. Vierordt himself is clear that the streaming is not formless and vague. The third stage might possibly be so construed, out of connection with stages 2 and 4, but in habitually changing to these its character is plainly revealed. Nor do the streams ever shift their paths hither and thither. Whatever Helmholtz may have seen, or however it may bear on this problem, Vierordt's observation cannot easily be misconstrued. It is one of the most definite descriptions of distinct and fixed stream-paths to be found in the literature of the circulation phenomenon. The report throughout conveys the impression of retinal capillaries and interspaces and circulating corpuscles, and Vierordt adopts these terms at the very beginning of his discussion as most fittingly characterizing what he saw.

O. N. Rood recommends the use of cobalt glass for the observation of the circulation phenomenon. Describing it, he says:[1] "The moving bodies at first appeared very closely packed together like fine mosaic work, but as the view grew more distinct their paths could be traced, and the conviction was forced on the mind of the observer, that they were moving at slow uniform rates through narrow channels, the whole reminding one strongly of the circulation seen in the web of a frog's foot through a microscope slightly out of focus." The indistinct vision attendant upon faintness or mere eye-weariness, is, he thinks, in many cases, mediately caused by the appearance of this circulation. For example, he tried the experiment of binding up the right eye and using only the left for two days. After reading with the left eye for half an hour, the page grew indistinct, the letters apparently dissolved, and the dense circulation which he had previously observed was set up, and continued to be visible for some minutes. Under these same circumstances it reappeared several times during that and the following day.

W. B. Rogers,[2] observing in co-operation with Rood, was able to get the phenomenon especially well after long or fatiguing work with the eyes, after active exercise, or indeed, after anything that stimulated the circulation. He describes it as follows: "When I look intently with the naked eye upon a bright surface such as that of a white cloud or a sheet of letter paper in the sunlight, the first appearance presented, is that of numerous bright points darting around in various broken curves, coming into view and disappearing fitfully, but in such positions as to indicate the recurrence of the same motions, or the passage of successive particles in certain pre-

[1] Silliman's *Amer. Journal of Science*, November, 1860, 385. See also the September number of the same year.
[2] *Ibid.*, 386.

scribed and permanent channels. As the eyes continue to be fixed on the surface, a shade comes over it, and on the dark ground innumerable streams of particles are seen, moving in infinitely various loops and other curves which, by a little attention, are observed to maintain a constant pattern, strikingly analogous to the capillary circulation as seen under the microscope. These streams of particles are of a tawny yellow as contrasted with the dark brownish surface on which they appear." He also gets the phenomenon very well by looking through a black tube at a white surface until the eye has become fatigued, or with the lens of a pocket microscope held at about the focal distance from the eye.

Aubert[1] says that when he presses lightly upon the ball of the eye he can see, with remarkable distinctness, the circulation in the vessels lying close to the yellow spot. The corpuscles move in single file along fixed paths. These paths form very small angles with each other, do not often anastomose, and frequently appear to cross each other without anastomosis. The size of the corpuscles is apparently about fifty times the size of the corpuscles in the capillaries of the frog's foot as seen under the microscope. Pulsations are plainly in evidence but become weaker as the pressure continues.

Describing the circulation as it appears in the visual field of his right eye, Helmholtz[2] reports that it is seen with remarkable clearness in two parallel vessels situated just to the left of the fixation point. The movement is "scheinbar nach oben gerichtet und das bewegte Gebilde verschwindet, indem es sich mit beträchtlich gesteigerter Geschwindigkeit durch eine S-förmige Krummung hindurchwindet." In both of these cases the vessels present a peculiar branched, tree-shaped appearance. The phenomenon often repeats itself, and sometimes in both vessels simultaneously. It occurs also, but less distinctly, at other places in the visual field. Helmholtz explains it as follows. Obstructions are formed here and there by large corpuscles, which dam up the capillaries in their more constricted portions. The corpuscles just in front of these obstructions move on, while those behind crowd against them, thus forming alternating translucent and opaque sections in the capillaries, which are seen as light and dark spaces. These suddenly dart forward or stop, according as the obstruction is overcome or reforms; and so arises the peculiar intermittent, darting movement that characterizes the capillary circulation as seen subjectively, or under the microscope.[3]

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[1] *Physiologie der Netzhaut*, 1865, 342.

[2] *Physiol. Optik*, 198 f.

[3] For other explanation see Rood (*loc. cit.*); Boisser: Landois and Stirling, Manual of Human Physiology, 1895, II, 995; and Ogden's criticism of Helmholtz (*loc. cit.*).

Ogden,[1] working in 1901, in addition to an introspective report, set for his observers the definite task of mapping the course of the blood-vessels. In his report two of these maps are published, showing the paths of both the large and the small streams, also the direction of the movement of the blood streams in them. Describing the phenomenon, his observer *B* distinguishes two classes of movement. In the one, taking place for the most part beyond the macular region, the spots moved rapidly over a considerable distance and scarcely more than indicated their general direction of motion. In the other, near the macula, they moved more slowly over shorter distances and described definite courses. Both corpuscle and path were plainly distinguished. Observations were made also of color and brightness of corpuscle and interspace.[2]

Other Movement Phenomena.

It is, of course, well known that, for the normal eye, the darkened field of vision is not black. It is covered unevenly with shifting, changing clouds of a luminous gray. Purkinje[3] employed the term *Lichtchaos* to cover in a general way this type of phenomenon. A frequent variety, which we shall need to consider here, has been called by Goethe[4] *wandelnde Nebelstreifen*. Purkinje (*loc cit.*) describes it as follows. When one stares into a carefully darkened field of vision, a faint, fantastic image appears and begins to move. At first it is variable and formless, but later it becomes more definite in outline. In general it consists of bands of light and shadow more or less arched, which move

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[1] This *Journal*, XII, 381-391.

[2] Space has not been given to the following reports because they do not add anything of importance to our discussion of those already given.

L. Reuben: On Normal Quasi-vision of the Moving Blood Corpuscles within the Retina of the Human Eye. Sill. Journ. (2), XXXI, 1861, 325-338. *Ibid.*, 417.

B. A. Pope: Entoptische Erscheinungen im Zusammenhang mit dem Blutkreislauf, Arch. f. Augen- u. Ohrenheilkde, I, 1869, 72-78, *Ibid.*, 459.

B. Becker: Ueber die sichtbaren Erscheinungen der Blutbeweg ungen in der menschlischen Netzhaut. Berlin, 1872.

S. E. Ayers: Der Blutlauf in der Gegend des gelben Flecks. Arch. of Opthalm. XI, 1882, 476. Arch. f. Augenheilkde. XIII, 1883, 29.

J. W. Barrett: Nature, LIII, 510.

G. J. Burch: *Ibid.*, 558.

For methods of mapping the retinal circulation see Ayres (*loc. cit.*); Ogden (*loc. cit.*); Randall, in de Schweinitz, Amer. Text-Book of Diseases of the Eye, Ear, Nose and Throat, 1889, 140; and O. W. Maher, Austral. Med. Gaz., IV, 38.

[3] *Beobachtungen und Versuche zur Physiologie der Sinne*, 1823, I, 58.

[4] *Farbenlehre*, Abth. 1, § 96.

"als concentrische Kreise gegen den Mittelpunkt des Sehfelds, und dort sich verlieren, oder als wandelnde Bogen an ihm sich brechen und in sich selbst zusammenkrümmen, oder als krumme Radien um ihn im Kreise sich bewegen." Its movement is slow. Eight seconds are usually required for one of the bands to run its course and disappear. From the beginning of the observation the darkness is never absolute. The field of vision is filled with a boundless chaos of weak light.

Observing more in detail, Purkinje distinguishes four cases of the phenomenon, which are described as follows. (1) A weak light in centripetal motion is seen in the centre of the field of vision. Surrounding this is a black band, which in turn is bounded peripherally by a belt of dull light. These move inward, and seem to displace the central luminous spot as a round dark area. Next the whole pattern (luminous ring, dark band, and faintly luminous, shimmering fringe) re-forms about this dark area, and, moving inward as before, takes its place. See Plate VII, figure 17.

(2) Broad luminous and broad black bands form alternately above the centre and move towards it. As they proceed they bend to form arcs which grow smaller and smaller, uniting into a single light-mass, and finally disappearing at the centre. See figure 18.

(3) Analogous to these are other patterns in which the light and dark bands extend either vertically or obliquely, and move towards each other. See figure 19.

(4) A fourth form consists of two-curved bands which extend from the middle point of the visual field in opposite directions, and turn about it. Later, after the attention has become fatigued, these patterns give place to irregular waves of light and shadow. Finally, these subside and there appears to be drawn over the visual field a scarcely perceptible veil of dull light.

PLATE VII

Showing Purkinje's drawings of the *wandelnde Nebelstreifen*: drawings 17, 18, 19.

Johannes Müller[1] describes the subjective lighting of the visual field somewhat differently. "At times the phenomenon appears as a general illumination of the field of vision. Again it takes the form of a bright shimmer, which spreads out in circular waves towards the periphery and vanishes. Frequently the shimmer is flecked, cloud-like and nebulous. And very rarely the phenomenon repeats itself with a sort of rhythm."

Volkmann[2] says that, when the eyes are closed and covered, the field of vision is seen to be filled irregularly with a sort of *Lichtstaub* which is present in different amounts under different circumstances. (Fechner, for example, after his prolonged investigation of the physiological colors got it in such excessive amounts for a year that he called it "*ein Lichtmeer*".) Color phenomena are also perceived, the colors, varying at different times. An observation made by Volkmann soon after awaking in the morning is reported as follows: "There was at first a shadow-field containing a small amount of light-dust which streamed from left to right. This light-dust increased, and a reddish centre formed in the shadow-field. The reddish centre became quadrangular in shape and spread out gradually over the whole visual field. In the centre of the red field thus formed, a green spot appeared, which likewise expanded, until it covered the visual field. Again a red spot developed at its centre, and spread as before. The red field of vision was thickly dotted or pointed, the points streaming from left to right." Sometimes violet and green were seen instead of red and green, and their order of succession frequently varied.

Aubert[3] describes the subjective light phenomena of the darkened field of vision as follows: (1) The field is never free from points and lines of light which move in a slow peculiar fashion. In appearance the patterns formed can be compared to floating strings of tow. The light mass is yellow in color, is not especially bright, and is variable in amount. (2) Goethe's *wandelnde Nebelstreifen* are often seen floating over the field in various directions. They are indefinite in form, and colorless. Eye-movement or blinking either hastens their movement or causes them to vanish. (3) At times, when the eyes are held especially steady, nebulous balls appear in the middle of the visual field. They alternately expand and contract, but do not move from place to place. They are brightest at the centre and shade off formlessly towards the periphery into the dark background. (4) Very bright points of light appear suddenly and vanish quickly. These points

[1] *Spontane Lichterscheinung im dunkeln Sehfelde:* Physiologie des Menschen, 1837, II, 391.
[2] *Wagner's Handwörterbuch der Physiolgie*, III, 1846, 311.
[3] *Physiologie der Netzhaut*, 1865, 333 f.

are so bright as to be mistaken for objective light. Under the most favorable conditions for observation, they cannot be seen more than a few seconds. (5) And fifthly, zigzag lines are sometimes observed, appearing either as bright, bluish, or violet flashes.[1] They move slowly and vanish after a few seconds. Aubert mentions also rotating shapes resembling comets, colored clouds, and "das eigenthümliche Strahlenschiessen von der Peripherie nach dem Centrum" which Ruete[2] has described. He says that long exposure to dark, so far from interfering with these phenomena, rather serves to intensify them.

Again, Helmholtz[3] reports the *wandelnde Nebelstreifen* as two systems of circular waves which slowly converge from both sides of the visual field towards its middle point. The locus of this middle point, he says, seems to be the entrance of the optic nerve. A certain periodicity obtains which, as it appears to him, roughly coincides with the respiratory rhythm. Lastly, Pierce[4] describes what he calls the "illusory dust drift." When one fixates a set of parallel white and black lines in a strong light for 20 sec. or more, and then transfers the gaze quickly to a square of dull black cardboard, the illusory dust drift may be seen. The appearance is that of a cloud of fine white dust moving across the field of vision in a direction in general perpendicular to the direction of the lines in the stimulus. When the stimulus is an uniform field, instead of lined, the drift does not occur. Pierce explains the phenomenon as an after-image of motion. The parallel lines solicit the eyes to move in a direction perpendicular to them. The numerous involuntary eye-movements thus set up give rise to after-images of motion when the eyes come to comparative rest on the uniform field of the black cardboard.—

It seems clear from this review that the writer was justified in regarding as new his observation of the streaming phenomenon. None of the movement phenomena mentioned agree in any essential particular with the streaming phenomenon. There are disturbances in the field of vision, secondary to streaming and out of the paths of the streams, which may possibly bear some relation to the shifting clouds, etc., of the retinal light; but there is no evidence that the streams themselves, with their definite stream forms, their shifting paths, and, still more distinctive, their characteristic effect on the visual processes, have hitherto been observed.

[1] For a description of the *Zickzacklinien* see also Purkinje, *Beobachtungen*, II, 84.
[2] *Lehrbuch der Ophthalmologie*, 1845, 72, figure 39.
[3] *Physiol. Optik*, 242.
[4] Studies in Space Perception, 331-38.

THE EFFECT OF SUGGESTION UPON THE REPRODUCTION OF TRIANGLES AND OF POINT DISTANCES

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HISTORICAL

It is generally recognized that every one is more or less influenced by suggestion. Experimental studies to determine the exact nature and amount of this influence, however, meet with considerable difficulty, owing to the artificial conditions which necessarily prevail in the laboratory. Especially is it difficult to devise a method of procedure which will afford an accurate measure of the effect of suggestion upon the reaction to visual stimuli.

Small,[1] in his study of the suggestibility of children, had a toy camel arranged with a rope around its neck in such a way that when he turned a windlass the suggestion was given that he was pulling the camel, though the latter did not move. Influenced by the suggestion 291 out of 381 pupils asserted that they saw the camel move. The percentage of effectiveness of the suggestion varied in the different grades tested as follows:

Grades	I	II	III	IV	VI	VII	Total
Percentage of illusion	96	81	80	70	34	71	76

The low percentage for VI is accounted for by the fact that the conditions were unfavorable for the illusion. In this experiment the mechanism of the windlass and the force of its pull were carefully explained beforehand and a high degree of expectation aroused, so that the asserted perception of movement was the result of the vivid idea.

Binet[2] reports an experiment, also on children, which is more closely allied to the present investigation. A line 50 mm. in length was shown by the director of a school to each pupil individually and the pupil was required to draw a line of equal length. In these reproductions there was a marked tendency to draw the line too short, seventy-eight out of eighty-six making it less than 50 mm. The reproductions varied in length from 28 mm. to 60 mm. The director then stated that

[1] Small, M. H.: The Suggestibility of Children, *Ped. Sem.*, Vol. 4, 1896, p. 182.
[2] Binet, A.: La Suggestibilitè. *L'Annèe Psych.*, Vol. 5, 1899, p. 99.

they would be shown a *longer* line, which they were to reproduce in like manner. The line which they were shown, however, was actually shorter, measuring only 40 mm. Only nine of the eighty-six drew the second line shorter than the first, and of these only one drew it 10 mm. shorter. In the case of the seventy-seven who followed the suggestion, the increase in the length of the second line over the first varied from 0 to 20 mm., with an average of 6 mm. The younger pupils showed a greater percentage of suggestibility than the older. The director then told them that they would be shown a third line a little *shorter* than the second, whereupon the original line of 50 mm. was presented again. This suggestion was less efficacious than the first, only seventy out of the eighty-six yielding to it. The amount of error was likewise reduced. Whereas in the first suggestion thirty-three showed a positive error of 5 mm. or more over the length of the original 50 mm. line, in the second only twenty-three showed as great a negative error below the 40 mm. line.

Pearce[1] tested the influence of a suggestive stimulus upon the extent of eye movements as indicated by visual localization. The subject, seated at the centre of a circle whose radius was 3½ feet, fixated a small square of white paper on the periphery directly in front of him. After 2 seconds another square was shown for 2 seconds at, *e. g.*, 30° to the right of the fixation point, and on its disappearance the subject turned his eyes to the point and indicated its location. As a suggestive stimulus a third square was shown 15° to the right or left of the second, the subject still keeping his gaze directed to the fixation point, and after the suggestive stimulus had disappeared the subject indicated the location of the second square. Five points were chosen from 30° to 69° to the right.

Without a suggestive stimulus there was an error of —0.4° to —6° (mean —3.2°), that is, the point localized was always to the left of the stimulus, the line of regard did not move far enough. When the suggestive stimulus was shown 15° to the *left* of the stimulus to be localized, the average error was —0.2° to —7.4° (mean —4.4°), showing a decided positive influence of the suggestion. When the suggestive stimulus was 15° to the *right* of the peripheral stimulus the average error was +1.2° to —6.5° (mean —2°), again showing a positive influence of the suggestion. Summing up his results Pearce notes that with a single peripheral stimulus the error toward the fixation

[1]Pearce, H. J.: Normal Motor Suggestibility. *Psych. Rev.*, Vol. 9, 1902, pp. 348-355.

point increases with the distance of the peripheral stimulus from that point. With the suggestive stimulus there is at first a tendency to resist the suggestion, but this diminishes as the suggestion is repeated. The resistance is most vigorous when the suggestion is contrary to the normal error, but ultimately the suggestion opposed to the normal tendency is most effective. The same person showed the highest degree of suggestibility in all of Pearce's tests, whether with visual, auditory or tactual stimuli.

The work which suggested the present investigation was that of Brand,[1] who tested the suggestive effect of printed mottoes on the reproduction of horizontal lines. These lines varied from 12 to 34 cm. in length and were represented by the interval between two pegs situated at a distance of 120 cm. from the eyes of the observer. The observer reproduced this interval by spacing two similar pegs on a ledge 40 cm. from his eyes. Of the four observers whose results are presented the first overestimated the distance when nonsense mottoes were shown, the second and third underestimated it, while the fourth reproduced it almost exactly. The effect of the "short" suggestion (mottoes containing the word "short," or "make short," or "make short enough") upon the first subject was to produce a slight negative error in the aggregate, while the "long" suggestion considerably increased the positive error. In the case of the second subject "short" suggestion caused a slight increase in the underestimation, while "long" decreased it. With both subjects the "long" suggestion was more effective than the "short." The fourth subject showed a positive error for "long" and an equal negative one for "short" suggestion. With all three of these subjects, therefore, the suggestion was positively effective. In the case of the third subject, however, "long" suggestion caused an increase in the underestimation, while "short" caused a decrease, *i. e.*, the effect of the suggestion was negative, the results being opposite to the nature of the suggestion. Here again the "long" suggestion was more effective than the "short."

More recently Smith and Sowton[2] have investigated the effect of what they called successive contrast. A modifying line varying from 2 to 20 cm. was shown and immediately afterward a standard line of 10 cm. was exposed. The length of the standard was marked off on a line already drawn on a sheet of paper. In all cases, both with and without the modi-

[1] Brand, J. E.: The Effect of Verbal Suggestion upon the Estimation of Linear Magnitudes. *Psych. Rev.*, Vol. 12, 1905, pp. 41-49.

[2] Smith, W. G. and Sowton, S. C. M.: Observations on Spatial Contrast and Confluence in Visual Perception. *Brit. Journ. Psych.*, Vol. 2, 1907, pp. 196-219.

fiers, the standard was underestimated, but for one of the two subjects modifiers of 2–10 cm. produced an average increase of 1.2 mm. in the estimation, while modifiers of 10-20 cm. caused an average decrease of 0.9 mm. That is, the shorter lines acted as a positive suggestion, the longer ones as negative.

Experimental

In the experiments now to be recounted the following apparatus was used. Upon a long table rested a black-lined box in the form of a truncated pyramid 8 × 12 cm. at the small end, 65 cm. square at the large end, and 185 cm. long. The large end was covered with black cardboard in the centre of which was an opening 25 cm. square, closed by a screen which could be raised and lowered at the pleasure of the operator. 15 cm. behind this screen was placed a frame to hold the cards upon which were drawn the forms to be reproduced. These cards were illuminated from the side by a four candle-power incandescent light, to secure constancy of illumination. The observer, seated at the end of the table, rested the forehead against a head-rest fastened to the small end of the box, and looked through the box at the cards. The latter were thus two meters from the eyes of the observer. The time of the exposure was two seconds.

Two kinds of suggestion were used, auditory and visual. The auditory suggestion consisted of a command, such as "make high," "make low," "make high enough," etc., or simply "high," "low," uttered in a firm tone of voice at the moment of exposure. The observers were requested to oppose no active resistance to the command, to allow their attitude to be as passive as possible so that the suggestion might have a chance to manifest its effect, yet they were asked to reproduce the figures as accurately as they could. For the visual suggestion a diamond-shaped figure 20 cm. long and 4 cm. wide (Plate I, Fig. XI) was shown on the frame, and immediately thereafter the form to be reproduced was exposed. As this diamond when shown in a vertical position was considerably higher than any of the forms, and as the shape of the figure was such as would probably cause an up and down movement of the line of regard, it was thought that it might serve as a "high" suggestion. On the other hand, when shown in a horizontal position the diamond-shaped figure gave a flattened out effect, so that it was called a "low" suggestion. To ensure this figure remaining in consciousness during the reproduction the observer was required to draw it with the greatest possible degree of accuracy as soon as the reproduction was made.

The forms decided on for reproduction were *A*. Triangles of different shapes and heights. *B*. Vertical point distances,

(1) Dots at given distances above the centre of a base line,
(2) Dots at like distances above another dot.

A. Triangles

Ten triangles of different shapes and heights were used, all having the same base of 10 cm. (See Plate I.) They varied from 49 to 100 mm. in altitude. Four were isosceles or nearly so, four were right or slightly acute, and two were obtuse, their apices projecting to the right of the base. The observer was given a sheet of paper 16×22 cm. with a base line of 10 cm. already drawn upon it, and was required to indicate with a pencil dot where the apex of the triangle would fall. Nine reproductions of each triangle were made with each kind of

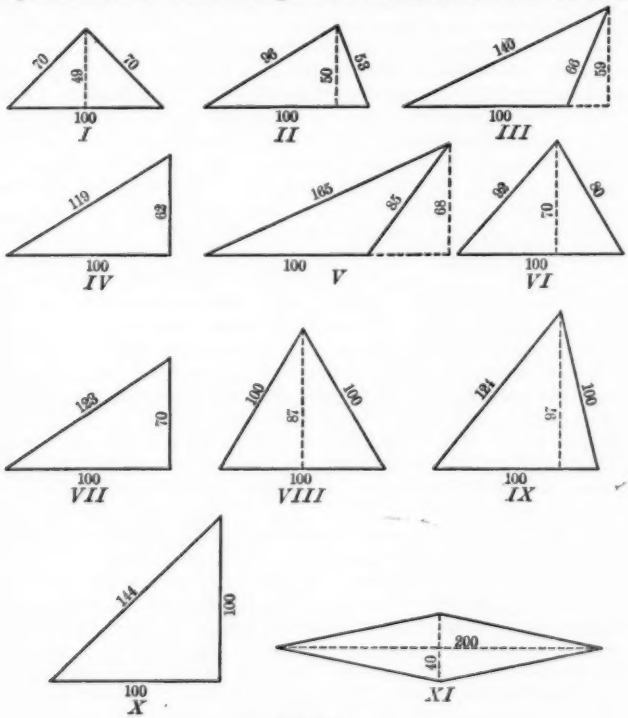

Plate I

The Arabic figures give the dimensions of the standard Triangles in millimeters.

suggestion, auditory and visual. The ten triangles were presented to the observer one after another in irregular order, and this constituted a series. Thus nine series composed a set. In order to obtain standards of reproduction for each observer without suggestion the first, fourth and seventh series of each set were given without suggestion, the triangles being presented in chance order. By taking the averages of these series as standards the practice element was practically eliminated. In the remaining series high or low suggestion was given in such a way that, while the order of the individual suggestions was quite irregular, when the set was finished each triangle had been shown three times with high suggestion and three times with low. Each leg of the reproduced triangle was measured and the altitude computed. This altitude was then compared with the altitude of the original triangle and the excess or deficiency expressed in millimeters as a positive or negative error. Six persons participated in this part of the experiment as observers, and are designated by the letters A, B, C, D, E and F.

Table I represents the average error in altitude of three reproductions of each triangle under the conditions of standard, high suggestion and low suggestion, for the two types of suggestion, auditory and visual, which were employed. The Roman numeral indicates the number of the triangle, and is followed by the actual altitude of each triangle expressed in millimeters. At the bottom of each column is indicated the algebraic sum of the average errors for all the triangles under the conditions indicated. This will be referred to as the aggregate error for each observer under the condition specified. To the right are columns showing the algebraic sum of the average errors of all observers for each triangle. This represents the aggregate error for each triangle under the conditions indicated. In the last column to the right is given the average error per observer for each triangle in the standard experiments, taken without regard to the direction of the error. This will be referred to as "average error of standard."

In inspecting this table it must be borne in mind that the observations of the auditory set were completed for all observers before the visual set was taken up, so that the latter tests were made several weeks later than the former. This fact, as well as the different attendant conditions (the one was taken in the midst of auditory, the other of visual suggestions) might be mentioned to account for the difference in standards which is observed in the two sets. If we try to compare these results of different observers for individual triangles we find great variation in the way the observers react to the same situ-

TABLE I. TRIANGLES

Auditory

No.	Alt.	A.			B.			C.			D.			E.			F.			Aggregate			Ave.
		St.	Sugg.		St.	Sugg.		St.	Sugg.		St.	Sugg.		St.	Sugg.		St.	Sugg.		St.	Sugg.		Error
	mm.		H	L		H	L		H	L		H	L		H	L		H	L		H	L	of St.
I	49	+9	+8	+1	−3	+13	−8	0	−2	−2	+10	+5	−3	+14	+9	+8	+2	−1	+1	+32	+32	−3	6.3
II	50	+2	+7	+5	−1	+6	−8	−3	−6	−7	+1	−5	−5	+1	+4	+2	−1	+2	−2	−1	+8	−15	1.5
III	59	+17	+18	+3	+2	+10	−2	−1	+6	−1	+7	−1	−6	+8	+15	+21	0	−1	−2	+33	+47	+13	6.
IV	62	+10	+9	+3	−2	0	−12	−1	−1	+6	+2	+2	−5	+7	+9	+3	−5	+4	−6	+11	+23	−10	4.3
V	68	+22	+18	+15	+3	+11	−9	+22	+1	+4	+1	+18	−7	+9	+18	+11	−2	+7	−3	+53	+73	+11	10.
VI	70	+11	+13	+10	+10	+8	−8	+4	−4	−4	+1	−1	−5	+10	+9	+4	+5	+7	+4	+41	+32	+1	7.
VII	70	+12	+6	+2	−10	+6	−12	−1	+1	−5	+8	+3	−6	+3	+6	−1	−1	−1	0	+11	+21	−22	5.8
VIII	87	+26	+8	+19	−4	+13	−9	+11	+1	+5	+7	+3	−8	+7	−1	+3	+2	+4	+4	+49	+28	+14	9.5
IX	97	+7	+9	+2	−9	+8	−20	−13	−8	−11	−10	−14	−10	0	+4	−3	−7	−11	−8	−32	−12	−50	7.7
X	100	−1	0	+5	−16	0	−28	−21	+4	−16	−8	−6	−15	+2	+3	+9	−12	−14	−7	−56	−13	−52	10.
Total		+115	+96	+65	−30	+75	−116	−3	−8	−31	+17	+4	−70	+61	+76	+57	−19	−4	−19	+141	+239	−113	

Visual

I	49	+5	+11	+6	+3	+15	−3	+3	+10	+9	+7	+5	+10	+2	+6	−11	+4	+4	+7	+24	+51	+18	4.
II	50	+4	+3	−1	+2	+20	+1	+3	+2	−2	+2	0	+3	+3	+2	+2	+1	+1	0	+15	+28	+3	2.5
III	59	+12	+3	+18	+5	+25	+10	+18	+14	+10	+7	−2	−5	+4	+4	−5	+2	+7	0	+48	+51	+28	8.
IV	62	+6	+8	+5	0	+16	+8	+7	+6	+12	+6	+3	−1	−2	−1	+2	−1	−1	+2	+16	+31	+28	3.7
V	68	+11	+31	+16	−3	+11	−7	+6	+15	+14	+7	+18	+23	+16	−21	+2	+4	+9	+6	+41	+63	+54	8.
VI	70	+11	+6	+11	−6	+14	0	+7	+8	+3	+2	−1	+4	+1	+2	+4	−2	0	+4	+13	+29	+26	5.
VII	70	+3	+5	+3	−2	+9	−8	0	+11	+13	+1	−4	+2	+3	−1	0	−5	−1	0	0	+19	+10	2.3
VIII	87	+13	+12	+3	0	+7	−4	+14	−1	+27	+13	+4	−1	0	−14	−6	+1	+3	+5	+41	+11	+24	7.
IX	97	−4	+5	−6	−11	+3	−23	+13	+4	−11	−8	−16	−15	−8	−9	−12	−5	−15	−7	−23	−28	−74	8.2
X	100	−3	+2	−9	−16	+2	−25	+19	−7	−2	−9	0	−7	0	−15	−7	−12	−12	+7	−21	−30	−43	10.
Total		+58	+86	+46	−28	+122	−51	+90	+62	+73	+28	+7	+13	+19	−47	−31	−13	−5	+24	+154	+225	+74	

ation. If we consider the aggregate error of all the observers for each triangle, however, some interesting things appear.

1. Triangles II, IV, and VII show the lowest aggregate as well as the lowest average error in the determination of the standards in both auditory and visual sets. These triangles were 50 mm., 62 mm. and 70 mm. in altitude, and their right base angles were 70°, 80° and 90° respectively. This agrees with the assertion frequently made by the observers that the right triangles seemed easier to reproduce and they felt that the results were more accurate than with the other triangles. In X, however, another right triangle with an altitude of 100 mm., the widest variation is shown, and the aggregate error is strongly negative. The next widest variation is found in V, an obtuse triangle with an altitude of 68 mm., where the aggregate error is as strongly positive. In general the obtuse triangles III and V were said by the observers to be the most difficult to reproduce and the results were felt to be the least accurate, owing, perhaps, to the lack of base line beneath the apical point. In triangles I, VI, VIII, and IX, which vary but little from isosceles, there is a considerable error both aggregate and average. In all cases, except the last, the aggregate error is positive, in IX, with an altitude of 97 mm., the error is as strongly negative.

2. If we consider the result of high and low auditory suggestion upon the aggregate error of each triangle, we observe that in all but three triangles (I, VI and VIII) the high suggestion produced an increase in the aggregate error over that of the standard, *i. e.*, was positively effective, and that in one of these three the amount remains the same. For the low suggestion the results are even more uniform, all triangles but one (X) showing a decrease below the standard. The total aggregate error for all the triangles shows an increase of 98 mm. above the standard for high suggestion and a decrease of 254 mm. below the standard for low suggestion.

3. The results for visual suggestion are not so uniform. Three triangles (VIII, IX and X) fail to show any increase for high suggestion, while four (IV, V, VI, and VII) fail to show a decrease for low suggestion. The totals for all triangles, however, show an increase of 71 mm. for high and a decrease of 80 mm. for low suggestion as compared with the standard.

In so far, then, we may conclude that in general the suggestions do affect the reproductions of the triangles, that the auditory suggestion is more effective than the visual, and that in the auditory set the low suggestion is more effective than the high.

But the chief interest of this investigation lies not in the

way in which this group of observers reacts as a whole to individual triangles, but rather in the effect of high and low suggestion upon the reactions of each observer. Here again we shall consider the nature and amount of the aggregate error of all the triangles for each observer in each situation.

1. Auditory set. Referring to Table I we note that the total aggregate errors for each observer are as follows:

TABLE II. AGGREGATE ERRORS. AUDITORY

		Suggestion	
	Standard	High	Low
A	+115	+96	+ 65
B	— 30	+75	—116
C	— 3	— 8	— 31
D	+ 17	+ 4	— 70
E	+ 61	+76	+ 57
F	— 19	— 4	— 19

An inspection of the standard shows that observers A, D and E exhibit a positive type of error, *i. e.*, tend to place the point higher than it should be. C in this particular set shows a slightly negative standard (—3), but as in all the other work C's standards are decidedly positive it is better to consider this as due to the abnormally large negative error which C shows in reacting to triangles IX and X, and to call C positive also. B and F are negative, *i. e.*, place the point too low.

Turning to the effect of the suggestion, we find that in every case the aggregate error for low suggestion lies below that for high, and in every case but one it lies below the standard. In the one exception (F) it just equals the standard. The amount of decrease below the standard varies from 0 to 87 (A 50, B 86, C 28, D 87, E 4, F 0). The low auditory suggestion, therefore, seems to have been effective with all observers. The high suggestion does not seem to have been so generally effective. In three cases (A, C, and D) the aggregate error fell below that for the standards, while only in the case of B (—30+75=105) did it rise far above the standard.

Visual set. The same types of reaction to the standards prevail here as in the above set. The low suggestion is effective in five cases in reducing the error below that for the standards. In the sixth case (F) there is a rise of 37. For the high suggestion the error fell below that of standards in three cases again (C, D, and E), and in all these cases it was even lower than the results for low suggestion. B again shows a strong rise (+150) above the standard.

In summing up the work on the triangles we may say that observer B alone showed striking susceptibility to the suggestion in all cases; that the susceptibility to low suggestion was

more general and more uniform than that to high; that A showed a considerable positive error throughout, and but for a few very low reproductions in the high suggestion would have shown a uniform susceptibility; that with three observers in each series any kind of suggestion, whether high or low, tended to reduce the estimate below that of the standards; and that in the visual series the reduction for high suggestion went even farther than that for low. Upon C, D, and E, therefore, it would seem that the vertical diamond-shaped figure did not act as a suggestion at all, but that its exposure before the triangle to be reproduced gave rise to successive contrast, *i. e.*, caused the following triangle to seem lower than it was. Yet the figure, when placed horizontally, was in as sharp contrast to the height of the triangles as when vertical, and in this situation its effect was in the nature of a low suggestion.

The observers were inclined to doubt whether either the auditory or the visual suggestion was having any effect upon their reproductions, but thought that if either did so it would be the auditory. Repeatedly they said that the visual suggestion merely bothered them, made them more uncertain in their reproductions, and increased their inaccuracy. Yet the results scarcely bear them out in this statement. The errors for visual suggestion are rather less in amount if anything than those for auditory suggestion.

At first there was a tendency for the auditory suggestion to arouse an attitude of expectant attention in the mind of the observer. At the command "make high" the observer involuntarily looked for a high triangle to reproduce. After a few trials, however, the conviction was established that there was no connection between the command and the triangle shown, and from that time on all expectancy was eliminated.

B. Vertical Point Distances

In the course of the experimentation with triangles it was frequently felt that the conditions of the experiment were complicated by the fact that the apex was not always in the same lateral position with reference to the centre of the base. A simplification was therefore decided upon, and two sets of experiments were carried out as follows.

1st. Dot above line. A base line 10 cm. long, bisected by a short stroke 2 mm. high, was drawn on each of ten cards. On each card, directly above the bisection, a dot was placed at a distance varying regularly from 2 cm. to 11 cm. from the line. These cards were so numbered from 1 to 10 that the distance from the point to the line in centimeters was always just one greater than the number of the card (*e. g.*, III = 4 cm., IX = 10 cm., etc.).

TABLE III. VERTICAL POINT DISTANCES

1. Dot above line. Auditory suggestion

No.	C.			D			E.			F.			Aggregate.			Ave.
	St.	Sugg. H	Sugg. L	St.	Sugg. H	Sugg. L	St.	Sugg. H	Sugg. L	St.	Sugg. H	Sugg. L	St.	Sugg. H	Sugg. L	Error of St.
I	+7	+2	−3	+1	+2	−1	+1	+4	+.3	+.3	−.3	+2	+9.3	+7.7	−1.7	2.3
II	−3	−4	−5	+6	+8	+5	+1	−1	−.3	−2	+3	−2	+2	+6	−2.3	3
III	+1	−3	+2	+7	+6	+5	+5	+4	+3	0	+2	+3	+13	+9	+13	3.3
IV	+7	+.3	+4	+3	+4	+1	+3	+7	+6	−4	+.3	+3	+9	+11.6	+14	4.3
V	+14	+14	+7	+2	+2	−.3	+15	+14	+18	−4	+3	+1	+27	+33	+25.7	8.8
VI	+17	+24	+16	+.3	−1	−2	+15	+29	+24	+2	+4	+3	+34.3	+59	+41	8.6
VII	+18	+13	+23	−2	−4	−4	+10	+15	+21	+4	+4	+8	+30	+28	+48	8.5
VIII	+13	+19	+18	+.3	+2	−.6	+20	+27	+19	−1	+1	+3	+32.3	+45	+39.4	9.3
IX	+32	+18	+7	−6	−13	−6	+24	+25	+27	−1	−4	+2	+49	+26	+30	15.8
X	+12	+21	+28	−13	−11	−10	+20	+28	+34	−5	−2	−3	+14	+36	+49	12.5
Agg.	+118	+107.3	+97	−1.4	−9	−12.9	+114	+152	+152	−10.7	+11	+20	+219.9	+261.3	+256.1	

2. Dot above dot. Visual suggestion

I	−.6	−3	+1	+8	+8	+7	+8	+3	+5	−3	−2	+.6	+12.4	+6	+13.6	4.9
II	+1	+12	+10	+8	+12	+11	+7	+5	+6	−1	+5	+4	+15	+34	+31	4.3
III	−2	+6	+3	+10	+11	+9	+12	+9	+16	−.3	+3	+1	+19.7	+29	+29	6.1
IV	+1.4	+5	+3	+9	+12	+16	+19	+18	+16	−2	+2	0	+27.4	+37	+35	7.9
V	−5	+5	−1	+5	+16	+8	+26	+18	+15	−5	+5	+6	+21	+44	+28	10.3
VI	+7	+6	+2	+10	+2	+5	+22	+29	+31	−8	+2	−3	+31	+39	+35	11.8
VII	−1	+1	+5	+6	0	+2	+22	+23	+20	−6	+3	−.6	+21	+27	+26.4	8.8
VIII	−2	−1	+9	+6	+.6	−4	+30	+31	+30	−7	−1	0	+27	+29.6	+35	11.3
IX	+2	+1	+2	+1	+3	−10	+29	+29	+35	−4	−.3	+3	+28	+33.3	+30	9
X	+10	0	+8	+1	−7	−.6	+18	+29	+38	−7	−8	−7	+22	+14	+38.4	9
Agg.	+10.8	+32	+42	+64	+57.6	+43.4	+193	+194	+212	−43.3	+9.3	+4	+244.5	+292.9	+301.4	

2nd. Dot above dot. On each of a like number of cards two dots were so placed that the conditions were the same as above except that the base lines were lacking.

These cards were observed through the box described above. In the first set the observer was given a sheet of paper with a 10 cm. line on it, bisected as the one on the card, and was asked to place a dot at the same distance above the bisection as the one shown on the card. In the second set the paper carried only a dot instead of the line. The procedure was the same as that for the triangles. Each set was shown to each observer nine times. The first, fourth, and seventh series were given without suggestion and the results for each card were averaged for the standards. The other series were given with high and low suggestion, the cards being taken at random, and now the odd numbers were given with high suggestion the even with low, now *vice versa*. It was intended to give both sets of dots with auditory and visual suggestion, but the work was interrupted when the dot above line set had been completed with auditory suggestion and the dot above dot set with visual. Thus the results are not directly comparable. Only observers C, D, E and F took part in the dot experiments. The average and aggregate errors are given in Table III. An inspection of the table reveals several interesting tendencies.

1. Standards. (1) Aggregates and average error for the different vertical distances. The aggregate error of all observers for each vertical distance is uniformly positive. This uniformity is much more marked than was the case with the triangles. Nor is it due altogether to the absence of results from A and B. This naturally raises the query whether the sides of the triangles, particularly of the higher ones, may not have something to do with the reduction of the error. Perhaps it is a case of overestimation of acute angles such as characterizes the Poggendorff and Zöllner illusions, the overestimation of the acute apical angle in this case causing a flattening in the appearance of the triangle. In some also a relation to the Müller-Lyer figure may be traced. To settle this question the present data are insufficient. It will be noted that both the aggregate errors and the average errors of the standards increase roughly with the increase in vertical distance, though the last distance (11 cm.) does not show the largest error in either set. Further it will be seen that the average error of the standards has a greater range and is more regular in its variation in the first set than in the second.

(2) Errors of individual observers. The same general types regarding the nature of the error in each observer were noted as in the work with triangles, *i. e.*, C, D, and E were positive, F negative. It is true. that in D's case the aggregate error

for all distances in the dot above line set is slightly negative (—1.4 mm.), but this is due to an exceptionally large negative error for the 11 cm. distance. Seven out of the ten distances show a small positive error.

The way in which the error manifests itself in the different observers is striking. C and E begin with a small positive or slightly negative error for the lesser distances in the dot above line and advance to a large positive error (+32 cm.) for the greater distances. E behaves in the same manner with the dot above dot, but C keeps a small error here and fluctuates about the zero point with a slight balance on the positive side. These facts are in accord with the introspection of the observers. Both C and E had a greater feeling of certainty in placing the dot at short distances from the base line. The farther they got from the base line the greater became their uncertainty. With E this was true of the dot above dot also. C, however, found it easier to record the distance between dots than between the dot aud the base line. The base line formed a distraction and the tendency was to outline a whole triangle, comparing the relative lengths of altitude and base, rather than to note merely the distance between the dot and the base line. D showed a small positive error in the shorter and medium distances in both sets, and, in sharp contrast to C and E, tended to go over into a negative error in the greater distances. D found it harder when only the dots were given, for, she said, "when a line was given I could measure the distance from the line to the dot by the length of the line, but when only a dot was given I had no measure." The same tendency, however, to go over into a negative error in the greater distances was observed in both sets. F showed a prevailing negative error in both sets and this tended to increase slightly with the greater distances especially in the dot above dot set. She, like C, felt surer of the distance between the dots than between the dot and line, yet her aggregate error is less for the latter than for the former.

2. Auditory suggestion; dot above line. There is little indication that the suggestion had any considerable effect. With C and D the low suggestion is lower than the standard, but the high suggestion, while higher than the low, is likewise lower than the standard. The result of either suggestion is to lower the error, the low being the more effective. With E and F, on the other hand, the opposite tendency is observed. The high suggestion gives an error higher than the standard, but the low suggestion produces an error just as high or even higher.

3. Visual suggestion; dot above dot. Here D and E maintain the same relative tendencies which they showed in the

auditory series, the former showing standard, high, low in descending order, the latter in ascending. C here changes decidedly to the ascending order, while F goes from an aggregate error of −43.3 for standard to +9.3 for high suggestion and drops back to +4.6 for low suggestion.

Discussion

Without doubt the most potent factor in cases of suggestion is the arousal of an attitude of expectant attention. In the experiments of Small and Binet pains were taken to arouse the highest possible degree of expectancy, and the whole of the illusion is referable to this attitude. In Pearce's experiment the result is due to shifting the attention from one stimulus to another, the reaction representing the resultant of both. If the focal idea is sufficiently dominating, and the situation does not offer too glaring a contradiction, there is almost no limit to be set to the amount of the illusion. In the present experiment expectant attention was gradually eliminated from the consciousness of the observer, and an effort was made to determine to what degree the mere sensory stimulus unwittingly influenced the reproduction. We have seen that with auditory suggestion in the triangles the influence was considerable, with the visual suggestion it was less marked, while with the dots the results were so contradictory as to be difficult of interpretation. This is due not to the changes in the conditions so much as to the time and practice elements. A somewhat similar decrease in the effect of the suggestion after repetition is observable in Binet's final trial. In our own experiments it seems to be a case of the motor power of ideas. In the first set, where the method of procedure was relatively novel, the idea aroused by the suggestion was sufficiently vigorous to influence the placing of the dot. But as the investigation proceded a twofold process of habituation took place. 1st. The habit of judging of the situation and placing the dot became more and more automatic, less affected by other idea groups. 2nd. The constantly reiterated suggestion, known to have no definite connection with the figure to be reproduced, roused an idea weaker and weaker in its motor power, until it had only a slightly disturbing or distracting effect upon the reaction. The observer thus became habituated to leaving this stimulus out of account.

Like Pearce, Brand, and Smith and Sowton we found striking individual differences in susceptibility to suggestion. Observer B was the most uniformly susceptible, followed closely by A. Observers D and F, on the other hand, show little sign of being affected by the suggestion even from the first.

Mention was made of the fact that Binet, and Smith and

Sowton found uniform and very striking negative errors in reproduction without suggestion, and that of Brand's subjects two were negative and but one positive. In our experiments, on the other hand, four observers are of the positive type and two negative, while the aggregates are strongly positive throughout. It must be remembered, however, that the other investigators employed horizontal distances while ours were all vertical. The difference in results may, therefore, be connected with the well known vertical-horizontal illusion, where if two lines of equal length, the one vertical, the other horizontal, be observed the vertical will appear the longer. Further, Brand found that in general the long suggestion was more effective than the short, whereas with us the low suggestion was more effective than the high. If we take this in connection with the prevailing types of error in the two cases the generalization would seem to be warranted that with the predominantly negative type the suggestion to increase the distance will be more effective, while with the positive type the suggestion to shorten the distance will have the greater efficacy. This is corroborated by an examination of the results for the individual observers in our tables.

Summary.

1. In reproduction without suggestion the aggregate error for all point distances and all triangles except IX and X was positive, *i. e.*, the observers tended to place the dots too high.

2. In the series without suggestion the type of error remained constant for each observer in all sets. All the observers were of the positive type except B and F.

3. There were decided individual differences in susceptibility to suggestion. B was the most susceptible, D and F the least.

4. The suggestions were most effective in the first set of experiments (triangles with auditory suggestion), less so in the later ones.

5. Low suggestion was more effective for the positive type, less effective for the negative type, than high suggestion.

A STUDY OF TEMPERAMENTS AS ILLUSTRATED IN LITERATURE[1]

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I

LITERATURE AS A CRITERION OF LIFE

In one way, that of the analysis and portrayal of temperament, good literature may be regarded as a fair criterion of conditions in real life; in fact, literature *is* good only when it seems, to discriminating judgments, to present humanity and its relations in a worthy and truthful manner. Matthew Arnold's statement that literature is a criticism of life will usually hold true.

Nevertheless, in the matter of the relative proportions of the various temperaments, the study of fiction and the drama tends to be somewhat misleading. As a usual thing, it is only the "interesting" types that the author cares, or, perhaps, dares, to use. The active, the gay, the romantic, the emotional—concerning these, he may feel sure, the reader ardently desires to be informed; the dull, the apathetic, the morose, the timid, the weak, or the merely ordinary, the author is perfectly aware, appeal to the public but little. These latter characters, then, he uses sparingly, or in an accessory way, as foils for the strong, animated and attractive, or as sources of annoyance to the injured innocent. Villains have always been in favor, provided that they were shrewd and vigorous enough, but the commonplace, well-meaning persons, the flabby and characterless, have been but slightly recognized in literature. This tends to be less and less the case, as humanitarianism increases, and the personality of the individual occupies a larger place in the minds of men. In other words, modern realism introduces into literature many characters which would formerly have been deemed unworthy of consideration. Modern fiction is, in this sense, a better standard of judgment in the matter of temperaments than those phases of character-portrayal which have preceded it. Yet it must be admitted, that while good literature describes and analyzes human characters with accu-

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racy and fidelity, it forms an extremely unsuitable means by which to estimate the proportions in which the various temperaments appear in the civilized world.

II

Ribot's Classification of Characters

This attempt to classify, on the basis of individual differences, some of the well-known characters of fiction is founded rather largely upon Ribot's discussion of normal characters in chapter 12 (Part II) of "The Psychology of the Emotions." Some modification of that scheme has, however, been deemed expedient. It will be remembered by those who are familiar with the chapter in question, that Ribot prepares the way for his classification by excluding from the catalogue of "true characters" the amorphous, or characterless; and the unstable, or vacillating. He then indicates "four degrees, of increasing definiteness and diminishing generality." Within the first of these, which is the most extensive and general (almost purely theoretical, in fact), he makes two great groups of characters: 1. The Active. 2. The Sensitive. After this twofold division, he is forced to admit the necessity for a third, which shall include those characters that are low both in feeling and in the impulses to action. This gives us: 3. The Apathetic. In the second degree come "the fundamental types of character," not merely theoretical, like those in the first degree, "but real, justified and verified by observation." In the third degree are the mixed or composite characters—those made up of elements from the three large groups. Here we find the sensitive-active, the apathetic-active, the apathetic-sensitive, the temperate or balanced (if there are any such, which Ribot appears to doubt). The fourth degree includes the "partial characters" for which we are given the formula: "Amorphousness, *plus* an intellectual disposition, or a well-marked affective tendency."[1]

Without indulging in any extended commentary on this scheme, which in the main seems reasonable, one may be allowed an expression of concurrence with the criticism of it that Malapert makes in his "Les Elements du Caractère." "It [the classification of Ribot] sins by default. It excludes too much." Have we the right to exclude the amorphous and the unstable on the ground that they are not real characters? They have a certain claim, by reason of their very peculiarities.

[1] This outline does not, of course, pretend to any classification of abnormal, or morbid characters, which are, according to Ribot, to be distinguished by means of his test of "unity and stability," and which he treats at some length in chapter 13.

Belonging to numerous reasonably normal human beings, they must constitute characters of some sort, just as a very ill-developed brain is nevertheless a brain. They seem, psychologically considered, to be as worthy as any other types; for as Malapert very wisely remarks, "Is character more than the moral physiognomy of the individual?"

In this paper, the more important character divisions, indicated by Ribot, have been adhered to, with, however, little effort to preserve a rigid observation of the "four degrees." The catalogue of "real" characters has been enlarged, to contain the amorphous, the unstable, and the temperate, or balanced character which Ribot regards somewhat doubtfully.

III

The Active Temperament

"The active," says Ribot, "have as their dominant characteristic a natural and continually renewed tendency to action. . . . Their life is mostly directed outwards. . . . They are optimists, because they feel strong enough to struggle with obstacles, and overcome them, and take pleasure in the struggle."

We need not search long in literature for examples of the mediocre and higher forms of the active temperament. D'Artagnan in "The Three Musketeers" of Dumas, serves admirably as an illustration of this type. His first adventures at the Court of Louis XIII are startlingly strenuous; the most noteworthy being the encounter with the Cardinal's guards. In this affray, D'Artagnan conducts himself with astonishing audacity and courage, finishing with his own hand an incredible number of experienced swordsmen. After this, duels, skirmishes, and bloody battles follow with appalling rapidity. The young Gascon no more than walks out for his dinner but he feels called upon to thrust his sword through a half-dozen ferocious enemies, of whom the supply never seems to grow less, despite his amazing achievements. There is no time for the hero to think, meditate, develop fine, differentiated emotions; no time for the author to describe them, if they existed. All is action, sword-thrusting, blood-letting, "swashbuckling." The feelings that play upon the surface of this exciting succession of events are the primitive ones—fear, courage, jealousy, hate, ambition, rude affection,—all in their simplest, least complicated form. The prime motive in the hearts of D'Artagnan and his daring companions is clearly the zest of life, the fine fervor of over-abundant spirits, the unbridled love of action, movement, excitement, and adventure.

Of the same enterprising, headlong, life-loving type are all

the heroes, little and big, of the usual historical novel; often, also, of the historical play. Witness Prince Hal, and Hotspur, two vigorous and lusty soldiers, joying in wild life, opposition, struggle, the battlefield. The Prince, who has a generous and very real comprehension of the character of his rival, thus sums up the passionate activity of Harry Percy: "I am not yet of Percy's mind, the Hotspur of the North; he that kills me some six or seven dozen of Scots at a breakfast, washes his hands, and says to his wife, 'Fie upon this quiet life! I want work!' 'O, my sweet Harry,' says she, 'how many hast thou killed to-day?' 'Give my roan horse a drench,' says he, and answers, 'Some fourteen . . . a trifle, a trifle!'" (Henry IV, Part 1, Act II, Scene IV.)

We might go through a long list of such knights of the sword and pistol: Quentin Durward,[1] Barry Lyndon,[2] Front de Boeuf,[3] Ivanhoe,[4] St. Ives,[5] David Balfour,[6] Henry Esmond,[7] Richard Carvel,[8] Hugh Wynne,[9] and a thousand others, as well known, or now fallen into literary obscurity. Some have more of one characteristic, some of another; some are merely roystering dare-devils, some polished diplomatists and gentlemen; but all are first and foremost distinguished by the love of action, the irrepressible desire for novelty and adventure, that leads them into and safely through the most prodigious and perilous of exploits.

The great-active temperament is that of the ordinary active, but more single-minded, more powerful, more exalted. In this class we must put all the epic heroes, and all great leaders of men, and makers of history, as they appear in literature worthy of their prowess. Hector,[10] Achilles[11], Odysseus,[12] Æneas,[13] Roland,[14] Siegfried,[15] Sigurd,[16] Arthur,[17] Beowulf,[18] the Cid,[19] and the Satan of Paradise Lost,[20] are all great actives. Hamilcar,[21] Cæsar,[22] Richard the Lion Heart,[23] William Tell,[24] and other such personal forces, may go in the same category. The great-active, though it may stoop to little things, has its vision on something far beyond the commonplace rewards of life—on the conquering or the restoration of a people, a nation, or a world. It is purposeful, vigorous, dauntless, and often (in the books), superhuman. It may

[1] Quentin Durward: Scott. [2] Barry Lyndon: Thackeray. [3] and [4] Ivanhoe: Scott. [5] St. Ives: R. L. Stevenson. [6] David Balfour: R. L. Stevenson. [7] Henry Esmond: Thackeray. [8] Richard Carvel: Winston Churchill. [9] Hugh Wynne: F. Wier Mitchell.

[10]-[11] The Iliad: Homer. [12] The Odyssey: Homer. [13] The Æneid: Virgil. [14] Chanson de Roland. [15] Nibelungen Lied. [16] Sigurd the Volsung: Wm. Morris. [17] Arthurian Legends. [18] Beowulf (the Anglo-Saxon Epic). [19] The Cid (the Spanish Epic). [20] Paradise Lost: Milton. [21] Salammbô: G. Flaubert. [22] Julius Cæsar: Shakespeare. [23] The Talisman: Scott. [24] Wilhelm Tell: Schiller.

itself be conquered, and even suffer death, but in the largest sense it is never really defeated; it transcends all that mere earthly strength can bring to pass. It is human possibility raised to the n^{th} power, and, in the older literatures, at least, embodies the ideal man approaching the potency and omniscience of the gods.

It will be noted that, so far in the discussion of the active type, only the names of men have been given. Are there, then, no active women, either in literature or in life? Doubtless there are more in real life than in the realms of fiction; yet it would be difficult to imagine a woman of the dominantly active temperament, such as D'Artagnan, or Henry Esmond, is seen to possess. The conventionalities have too firm a hold upon the sex, for one thing, and a women's nature is too inherently emotional, for another. Even though she may, by taste or necessity, be distinctly active, in whatever polite way is permitted, she is bound to be dominated by her feelings. The woman who is the exception to this rule, though she may be a valuable member of society, is not usually attractive and romantic enough to be made the heroine of a novel. She may take the place of a subordinate character, but that is all. Tom Grogan, in the book of that name by Hopkinson Smith, is a woman who leads an active, masculine life—but yet a woman. Priscilla Lammeter [1] and Betsy Trotwood [2] might be spoken of as active women, yet they are consigned to the position of inferior, half-humorous characters in the books in which they appear. The dearth of purely active feminine types in literature is significant of several things: First:—That the emotional or emotionally active women are the only ones really interesting to the average, or even the intelligent reader. Second:— That the usual masculine writer (and up to a few years ago, practically all writers were masculine) sees woman only as an emotional subject, because he regards all women as different, in mental constitution, from his own sex. Third:— That the usual feminine writer sees woman only as an emotional subject, since she knows all or nearly all, women to be like herself. Fourth:— That women are, actually, by birth and training, emotional and not pre-eminently active.

Thus it is easy to see why, though there are plenty of sensitive-active women in literature (as will be shown later), there is an extremely small number in whom activity may be said to dominate.

IV

The Sensitive Temperament

Within the genus of the sensitive, Ribot distinguishes three species: The humble; the contemplative; the emotional.

[1] Silas Marner: G. Eliot. [2] David Copperfield: C. Dickens.

The first of these, the humble, is characterized by "excessive sensibility, moderate intelligence, and little or no energy." Such a personality is rarely found in fiction; it is difficult to handle, and does not attract the author whose chief purpose is to please his readers. It is to the work of a Balzac that we instinctively turn, to find an example of such a character as the sensitive-humble, disregarded by the generality of literary men. "Cousin Pons" meets the requirements precisely. Pons is a bachelor, somewhat advanced in years, a musician and a collector of rare and beautiful objects, for which he spends the greater part of his scanty income. He has, the author tells us, "a great soul, a sensitive nature."

"The sense of beauty which he had kept pure and living in his inmost soul, was the spring from which the delicate, graceful and ingenious music flowed, and won him reputation." "A masterpiece finely rendered, brought tears to his eyes."

This "tender, dreamy and sensitive soul" is condemned to loneliness. The few relatives whom Pons can claim are stolid or malicious creatures, incapable of any understanding of the gentle bachelor's nature. "He had," says Balzac, "suffered acutely among them, but like all timid creatures, he kept silence as to his pain; and so by degrees, schooled himself to hide his feelings, and learned to take sanctuary in his inmost self." "Who will ever paint all that the timid suffer?"

The wretchedness which even trifles could cause him is compared to the irritation of some harsh substance on a delicate membrane. "Invisible grains of sand sank perpetually into the fibres of (his) being, causing . . . intolerable anguish of heart."

On the occasion of a visit paid by the old man to his stupid and mercenary cousin, "Pons suffered from the inexplicable emotions which torment clear consciences—from a panic terror such as the worst of scoundrels might feel at sight of a policeman; an agony caused sorely by the doubt as to Madame de Marville's probable reception of him." At some carelessly brutal remark from the same cousin, "Pons flushed red, like a girl found in a fault. The grain of sand was a little too large; for some moments he could only let it work in his heart."

Here is the perfection of the sensitive-humble type; we need seek no better illustration than this shrinking, palpitating, self-distrusting old soul, so exquisitely depicted by the hand of him who has been successful above all others, in the delineation of elderly men.

Pére Goriot, another of Balzac's characters, is very similar to Cousin Pons. He is retiring, self-sacrificing, delicately impressionable, a victim of his own generosity and the selfishness of others. Neglected and ill-treated by his daughters, to

whom he has given all, he represents in his lonely and pitiable death the tragedy of the sensitive-humble character in an unregardful world.

Brutus[1] is an excellent example of the sensitive-contemplative character, though perhaps not so striking as the much-discussed and never perfectly analyzed Hamlet. Brutus is always the thinker, the man of speculative imagination; yet his thoughts and imaginings are always tinged with feeling—with sincere affection for his relatives and friends, with kindliness for servants and attendants, with passion of noble action or fervor of patriotism. He does nothing in the rashness of personal enmity, nor is he moved to outbursts of wrath and spleen, as Cassius is. He ponders all his deeds, weighs every consequence, and considers every possibility. When he acts, it is only after long inward discussion and the wearisome comparison of right and wrong. He never strikes out boldly, as the man of action does; nor, on the other hand, does he shrink from a strenuous duty, as the mere emotional weakling is prone to do. Though moved by strong emotional impulses, he debates long within himself, as to a proper course of action and having decided what is right, holds rigidly to it, to the end.

The Buddha of Edwin Arnold's "Light of Asia" is a most satisfying example of the sensitive-contemplative type. Gentle, affectionate, full of love and ardor for his family and friends, he yet withdraws from the world into a life of meditation,

> "Seeking, night and day,
> * * * that light which somewhere shines,
> To lighten all men's darkness, if they knew:"

Lost in contemplation he passes to vision after vision of

> "Life's upward steps, long linked
> To higher slopes and higher,"

The man rapt in his holy thoughts becomes at last the mystic and the seer.

Other illustrations of the type may be found in literature of greater or lesser worth. Hamlet has already been mentioned. Job never ceases to fascinate, with his long and well-nigh unendurable afflictions, his restless searching after truth, his wistful, half-skeptical questioning, "If a man die shall he live again?" Christian in the "Pilgrim's Progress" is a sensitive contemplative; so is Silas Marner in George Eliot's great novel; and in the same list with these we shall be justified in putting Dr. Primrose,[2] Robert Elsmere,[3] Dr. Lavendar,[4] and John Ward, Preacher.[5]

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[1]Julius Cæsar: Shakespeare.
[2]The Vicar of Wakefield: Goldsmith. [3]Robert Elsmere: Mrs. Humphrey Ward. [4]Old Chester Tales, Dr. Lavendar's People: Margaret Deland. [5]John Ward, Preacher: Margaret Deland.

The sensitive-emotional temperament finds a fitting embodiment in the Werther of Goethe.[1] Werther is above all things the man of feeling. He seems almost incapable of action, so much are his mental powers concentrated on his own states of emotion. He appears to be endowed with talents, particularly the artistic, of which, in his letters, he occasionally speaks. Even before he is permitted that first fatal view of Charlotte cutting bread and butter for her flock of brothers and sisters, he is seen to be highly emotional, and imaginative to an extreme degree. He confesses that he has ever been the subject of sudden transitions from sorrow to immoderate joy, and from sweet melancholy to violent passions. After he becomes possessed by that unhappy affection which works his utter undoing, we behold him with eyes in a fine frenzy rolling, carried away by the violence of his love.

On one occasion, he tells us, overcome by a force of a purely imaginary circumstance, he buries his face in his handkerchief, and hastens from the room.

"If Charlotte," he says, "does not allow me to enjoy the melancholy consolation of bathing her hands in my tears, I feel compelled to tear myself from her. Then I either wander through the country, climb some precipitous cliff, or force a path through the trackless thicket, where I am lacerated and torn by briars, and thence find relief."

Again, in writing to his friend Wilhelm: "O, why cannot I fall on your neck, and with floods of tears and raptures give utterance to all the passions that distract my heart?" He relates an instance in which Charlotte figures: "I threw myself at her feet, and seizing her hand, bedewed it with a thousand tears." He becomes a pessimist, as those who feel deeply must inevitably do. "What is the destiny of man," he questions, "but to fill up the measure of his sufferings, and to drink his alloted cup of bitterness?" Yet he of all the world appears to himself the most miserable. "Have men before me ever been so wretched?" he exclaims. And so on, through fits and gusts of passion, wails and ravings of despair, we follow him to the end, when he takes his wretched life with the pistols which his last letter tells us he has kissed a thousand times, because the white hand of Charlotte has but touched them.

It is said that Werther has been responsible for many suicides in addition to his own. This is easy to believe. In the sentimental age in which the book was written, there may, indeed, have been many who, impressed by the fervor and eloquence of the passionate young artist, were persuaded that they, too, had griefs too bitter to be borne. But in this matter-

[1]The Sorrows of Werther: Goethe.

of-fact age there are few who can read "The Sorrows of Werther" without a certain impatience, even mirth. He is the emotional hero *par excellence*, but the time has gone by when such heroes can make their appeal.

Of the sensitive type but more attractive and lifelike is Lucy Snow, in Charlotte Brontë's delightful novel, "Villette." Lucy is frankly emotional, yet full of intelligence, and, usually, of self-control. She has little impulse to action, and never takes an initiative unless forced by necessity to do so; she rather remains passive, feeling intensely, yet doing nothing, until a desperate situation of some sort compels her to take a new course. She suffers much, not particularly from ill treatment, or even unkindness, of which she has an undue share, but from the sensitiveness of her own soul, which torments itself with questions, reproaches, vague imaginings, and passionate desires. To the looker-on, a small, plain, quiet English teacher in a busy and pretentious Belgian *pensionnat*, she is in reality the central figure in a long series of emotional dramas—all enacted within the chambers of her own brain. She has a highly wrought, keenly susceptible nature, yet, lacking neither spirit nor humor, she never seems exaggerated nor artificial. She is, indeed, one of the most natural, as well as one of the most skillfully analyzed emotional figures in all modern literature.

Jane Eyre[1] is much like Lucy Snow, though perhaps somewhat more intense. There is a long list of sensitive-emotionals in fiction and the drama. Corinne[2] is noteworthy; so is Clarissa Harlowe[3]—a figure of almost pure emotion. Juliet[4] is all ardor and sensibility—a most fitting companion for the youthful Romeo; Ophelia,[5] Desdemona,[6] Miranda[7] and Viola,[8] not to mention others of Shakespeare's women, may well be said to come within the catalogue of emotional. Cyrano de Bergerac,[9] Heathcliff,[10] Rochester,[11] Arthur Dimmesdale,[12] Claude Melnotte,[13] though it may sound incongruous to group them together, are sensitive-emotional men. Nydia,[14] Evelina,[15] Pamela,[16] Tess of the D'Urbervilles,[17] Jeanie Deans,[18] Hester Prynne,[19] Lindel of the "African Farm,"[20] and the emotional heroines of the so-called "love stories" are of this

[1] Jane Eyre: C. Brontë. [2] Corinne: Mme. de Staël. [3] Clarissa Harlowe: Richardson. [4] Romeo and Juliet: Shakespeare. [5] Hamlet: Shakespeare. [6] Othello: Shakespeare. [7] The Tempest: Shakespeare. [8] Twelfth Night: Shakespeare. [9] Cyrano de Bergerac: Rostand. [10] Wuthering Heights: Emily Brontë. [11] Jane Eyre: C. Brontë. [12] The Scarlet Letter: Hawthorne. [13] The Lady of Lyons: Bulwer-Lytton. [14] The Last Days of Pompeii: Bulwer-Lytton. [15] Evelina: Miss Burney. [16] Pamela: Richardson. [17] Tess of the D'Urbervilles: Thomas Hardy. [18] The Heart of Midlothian: Scott. [19] The Scarlet Letter: Hawthorne. [20] The Story of an African Farm: Olive Schreiner.

type, as well as many in books of higher excellence. It may truly be said that the common feminine type in literature is the sensitive-emotional as the common masculine type is the active.

V

The Apathetic, the Amorphous, and the Unstable

Of the really apathetic character we see but little in literature, chiefly, perhaps, because it does not make interesting reading. It is apparent, nevertheless, in a few well-marked cases. One of the most typical of these is Minoret-Levrault in Balzac's "Ursule Mirouet." He is a heavy, repulsive person, lacking in both activity and emotion. His wife, Zèlie (an apathetic-active, it would seem), completely dominates him, scheming and plotting for the advancement of the family, and managing everything according to her own very narrow and very selfish ideas.

"Wherever form rules," says the author, "sentiment disappears. The postmaster, a living proof of that axiom, presented a physiognomy in which an observer could with difficulty trace beneath the vivid carnation of its coarsely developed flesh, the semblance of a soul, . . . Though . . . quite incapable of reflection, the man had never done anything that justified the sinister suggestions of his bodily presence. To all who felt afraid of him, his postilions would say, 'Oh, he 's not bad.' He seldom spoke. . . . If he had been a talker you would have felt that he was out of keeping with himself. Reflecting that this elephant minus a trumpet, and without a mind was called Minoret-Levrault, we are compelled to agree with Sterne as to the occult power of names, which sometimes ridicule, and sometimes foretell character."

It is needless to say that the sluggish and unprepossessing postmaster is not the most interesting character in the book.

On the whole, the pure-apathetic type must of necessity carry with it a suggestion of stupidity. There is something abnormal, also, about it, for it is the nature of the normal man either to feel or do—or to both feel and do. Usually, in literature, the apathetic person has some moving impulse within him, which puts him into the list of apathetic-actives, or that of partial characters. Bovary, for instance, in Flaubert's great novel, "Madame Bovary," would be set down as an apathetic were it not that his simple, but deep and intense love for the unworthy woman he has married gives him a claim to a somewhat higher place. Dunstan Cass, in George Eliot's "Silas Marner," is of an apathetic temperament, yet once or twice he acts with vigor and decision. Dombey, in Dickens's "Dombey and Son," approaches the apathetic, but exhibits on certain

occasions an ability to feel and do that makes us hesitate in our classification of him. The apathetic temperament in the normal man is, it would seem, best distinguished in combination with elements of a distinctly different sort.

The amorphous characters approach the sensitive-emotional on the one hand and the apathetic on the other; ordinarily there may be some difficulty in distinguishing them. A notable example is, however, ready at hand, which represents rather clearly what Ribot means when he says of the amorphous, "Some other person, or failing that, the social environment, wills for them, and acts through them. They are not voices, but echoes." This character is seen in Gertrude, Queen of Denmark, the mother of Hamlet. Her first utterance in Shakespeare's play is a commonplace, a cheap platitude, acceptable only to shallow minds:

> "Do not forever with thy vailèd lids
> Seek for thy noble father in the dust;
> Thou knowst 'tis common; all that lives must die,
> Passing through nature to eternity."

"Ay, Madam, it is common," answers Hamlet, sensible for the moment that to try to explain real and lasting grief to a nature like the queen's is a useless and thankless task.

"If it be," continues his mother, "why seems it so particular with thee?"

Hamlet's patience gives way. Here is a woman whose husband is less than two months dead, who is able to console herself, and now attempts to console him with a meaningless formula caught from other lips, perhaps those of the "borrowed majesty of Denmark." The young man bursts forth into passionate reproach:

> "Seems, Madam! nay it *is!* I know not seems!"

But the truth and eloquence of his speech are lost upon the shallow queen. The remainder of the play goes to show her almost utter lack of individuality. When Hamlet, in the closet scene, attempts to show her the heartlessness and iniquity of her conduct, she seems at first unable to comprehend his point of view, but soon, with characteristic adaptability, acquiesces completely in what he says, suiting her attitude to his words, and promising anything he asks. No sooner, however, is she out of the circle of his influence than she is again the easy tool of the king, and the reflection of the conventionality and corruption of the court.

She is not the apathetic type, for she has feelings, such as they are, of a rather fleeting nature; she seems to care sincerely for Hamlet, and shows real affection for Ophelia. She is not the unstable, exactly, for she is not within herself changeable or capricious; she is altered by the influence of others, of

more powerful personality than herself. She is not the sensitive-emotional, because her feelings are never deep enough nor strong enough. There seems no doubt as to the justice of classifying her as almost purely amorphous.

The following characters may be classed as amorphous though some of them, it must be confessed, might as reasonably be called partial characters: Genevra Fanshawe,[1] Amelia Sedley,[2] Cosette,[3] Marius,[4] Ursule Mirouet,[5] Stephen Guest,[6] Agnes Wickfield,[7] Hetty Sorrel,[8] Lucie Manette,[9] Lucy Deane.[10]

Capriciousness, uncertainty, lack of poise are characteristic of the unstables. There is no predicting what they will do. They surprise us with sudden changes—unexpected outbursts of malice, kindliness, devotion or self-sacrifice. They add an element of speculation to a story in the very fact that we cannot depend upon them from one moment to another. Nevertheless, they are often irritating because they allow us no settled attitude or verified opinion regarding them. The unstable character as a hero is likely to prove a very unsatisfactory being. Of the truth of this statement we need no further evidence than Mr. Barrie's "Sentimental Tommy," with its tantalizing and disagreeable sequel, "Tommy and Grizel." As a child, Tommy is undeniably attractive, as we expect but little of an infant, or even of a half-grown boy, in the way of stability and unity of character. But as a man, he is not much less than repellant. His explosive, fickle, unreliable character makes him almost as intolerable in fiction as a person of his nature would be in an actual social circle. More successful, because not so completely variable is the character of Sidney Carton, in Dickens's "Tale of Two Cities." His one supreme act of renunciation, surrounded as it is by the pathos of unrequited love, wins for Carton our sympathy and lasting approbation, setting him somewhat above the fairly conventional hero, Evremond. Steerforth, in "David Copperfield," is of an unstable temperament. So, most decidedly, is Peer Gynt, in Ibsen's drama of that name. Godfrey Cass[11] and Arthur Donnithorne[12] are examples among George Eliot's characters. King Lear, though one of Shakespeare's greatest creations, is, nevertheless, of the unstable type. "He hath ever but slenderly known himself," says his daughter, with her cool, unlenient judgment. "The best and soundest of his time hath been but rash." The inconstant character in fiction as in real life, encounters everywhere sorrow and disaster. His condemnation is that of

[1]Villette: C. Brontë. [2]Vanity Fair: Thackeray. [3]-[4]Les Miserables: Hugo. [5]Ursule Mirouet: Balzac. [6]The Mill on the Floss: G. Eliot. [7]David Copperfield: Dickens. [8]Adam Bede: G. Eliot. [9]A Tale of Two Cities: Dickens. [10]The Mill on the Floss: G. Eliot.
[11]Silas Marner: G. Eliot. [12]Adam Bede: G. Eliot.

Reuben,[1] who heard among the lofty phases of his father's blessing, the sad, inevitable words, "Unstable as water, thou shalt not excel."

VI

Composite Characters

The apathetic-actives are closely allied to the apathetic-intellectuals, and it is difficult to make any clear distinction between them. The intellectuals, however, seem to lack a certain spontaneity, or inner source of action, which the apathetic-actives possess. The chief difference between these active temperaments and the ordinary active, is that the former have less than the ordinary amount of feeling. They are "cold-blooded" as we say. They have one strong passion, as selfishness, or religious fanaticism, but, otherwise, are not responsive to emotional appeals. There is no kindliness, tenderness, nor pity in them; they are unable to put themselves, mentally, in the place of another who is experiencing joy or pain. They make others suffer, even administer torture, without any qualms, either æsthetic or conscientious. An illustration of this temperament appears in the Richelieu of De Vigny's "Cinq-Mars" and Bulwer-Lytton's "Richelieu." He is cold, calculating, impervious to any appeal which touches the usual man. He possesses a brilliant intellect, which he uses to promote his own cruel and fanatic purposes. He allows nothing to interfere with his own designs, but sacrifices the young, the promising, the innocent,—any one whom he deems capable of putting a stone in his way. We recoil in horror from such a soul. It seems, and justly, to be nothing less than hideous, not entirely human but fiendish.

Much the same character is shown in Iago, in Shakespeare's play "Othello." He seems devoid of feeling, except for a certain tinge of ambition and jealousy. He is cold-blooded, conscienceless, but indefatigable in his labor to prosper his evil cause—in short, he is an apathetic-active.

Others who partially or completely possess this unenviable temperament are Richard III,[2] Goneril and Regan,[3] Becky Sharp,[4] Tito Melema,[5] Madame LaFarge,[6] Madame Thenardier,[7] Roger Chillingworth,[8] Javert,[9] and Fagin.[10] Certainly a much longer list might be made. In many, a close inspection would reveal a near approach to the morbid and unnatural;

[1]Genesis, 49, 4.
[2]Richard III: Shakespeare. [3]King Lear: Shakespeare. [4]Vanity Fair: Thackeray. [5]Romola: G. Eliot. [6]A Tale of Two Cities: Dickens. [7]Les Miserables: Hugo. [8]The Scarlet Letter: Hawthorne. [9]Les Miserables: Hugo. [10]Oliver Twist: Dickens.

many at the best would have to be set down as partial characters.

By far the most usual, as well as the most interesting character-combination in literature is the sensitive-active. So large a representation has this temperament that one must select merely at random.

Anna Karénina in Tolstoi's novel which is named for her, is not less interesting than others of her kind. The emotional heroine of an emotional novel, she, nevertheless, impresses one as a strong, vital, active character. Our first glimpse of her convinces us of her "dignified vivacity," as the author puts it. "There seemed to be in her person," he goes on, "such a superfluity of life that in spite of her will, it expressed itself now in the lightning of her eyes, now in her smile." We feel her energy and capability at once, in the way in which she adjusts the domestic difficulties of her brother, Stepan Oblonsky, and his wife. Everything that she does bears the impress of a vigorous and unwearying nature. She delights in action as a thoroughbred race-horse delights in it. Yet she is full of emotional ardor and sensibility which suffuse her action, and give her the most undeniable womanly charm. The less sensitive, the happier she might have been—the more contented with her unromantic husband, and less susceptible to the charms of the distinguished Vronsky. She suffers agonies of jealousy, of affection, remorse, and despair. She finds her life as she has made it for herself, unendurable; but even in seeking death, she is actuated, not so much by her wild yearning for relief from pain as by the logical conviction that no other course is open, and by a sort of desperate courage concentrating in one strong and decisive moment the tempestuous vigor and passion of her life.

As has been suggested, there are many sensitive-actives. An extra dash of sensitiveness, if the character is a woman, a trifle more of activity, if the character is a man, will produce the proportion which impresses most of us as fitting, proper and true to life. The struggles and unhappiness of Maggie Tulliver[1] draw largely upon our sympathy, for she seems to us a real person, burdened with actual griefs, and performing actual deeds. Katusha in Tolstoi's tremendous book "Resurrection" holds us in a still stronger way. Lady Macbeth,[2] Antigone,[3] Alcestis,[4] are characters capable of deep feeling and great action. Œdipus,[5] Savonarola,[6] Macbeth,[7] are exalted names of men who could both feel and do. The list is long:

[1]The Mill on the Floss: G. Eliot. [2]Macbeth: Shakespeare. [3]Antigone: Sophocles. [4]Alcestis: Euripides. [5]Œdipus Rex: Œdipus at Colonus: Sophocles. [6]Romola: G. Eliot. [7]Macbeth: Shakespeare.

Lorna Doone,[1] Robert Falconer,[2] Richard Feveril,[3] Jean Valjean,[4] Romola,[5] Rebecca,[6] Ramona,[7] M. Paul Emanuel,[8] David Copperfield,[9] Edgar,[10] Rosalind,[11] Dinah Morris[12]—and many others whose names it would take long to set down. Some of these approach the balanced temperament, others are more purely emotional, yet all are undoubtedly sensitive-actives.

Of the existence of the balanced character, Ribot confesses himself uncertain. He suggests that if there is a person in whom feeling, thought, and action are nearly or quite equal, this condition would result in suppresion of character, *i. e.*, of any marks of individuality. It is difficult to admit that such need be the case. It would seem that character *per se* must still continue; for is it, as Malapert suggests, anything more than the "moral physiognomy" of a given human being?

Whether or not persons of the balanced character exist in real life, there are plenty of them to be found in books. The one that most readily occurs to us is Sir Charles Grandison in Richardson's famous volumes of that name. The preface written by the author sets forth quite clearly his own modest intention, and the prospective character of his hero.

He "now presents (he says) in Sir Charles Grandison, the example of a man acting uniformly well through a variety of trying scenes, because all his actions are regulated by one steady principle. A man of religion and virtue, of liveliness and spirit, accomplished and agreeable, happy in himself and a blessing to others." Mark the perfect man!

From the outset, what may we expect of such a hero but the most irreproachable manners, the most impeccable virtue, the highest, the most unassailable honor—and in general, the most correct and tiresome behavior? These indeed, are exactly what we find, Sir Charles is so flawless, so "icily regular" so "splendidly null" that the first three volumes would seem sufficient to establish his claims to canonization, without the need of the other three or four. It takes him a long time, however, to condescend to bestow his evenly pulsing heart upon the most angelic, yet palpably unworthy, Miss Harriet Byron. In the meantime this periwigged, lace-trimmed, silk-stockinged paragon conducts himself in a manner quite in accordance with the author's preface. On one of the early pages of the book, he coolly disposes (for the time, at least) of the

[1]Lorna Doone: Blackmore. [2]Robert Falconer: G. Macdonald. [3]The Ordeal of Richard Feveril: G. Meredith. [4]Les Miserables: Hugo. [5]Romola: G. Eliot. [6]Ivanhoe: Scott. [7]Ramona: Jackson. [8]Villette: C. Brontë. [9]David Copperfield: Dickens. [10]King Lear: Shakespeare. [11]As You Like It: Shakespeare. [12]Adam Bede: G. Eliot.

arrant villian, Sir Hargrave Polfexen, who is summarily abducting the heroine with a view to forcing her into marriage. Sir Charles, without descending from his customary dignity, stops the horses, vanquishes the villain, and rescues the lady. This he does with a delicious nonchalance. "I had not drawn my sword," he remarks, in relating this little adventure to an adoring circle of femininity; "I hope I shall never be provoked to do it in a private quarrel. I should not, however, have scrupled to draw it on such an occasion as this, had there been absolute necessity for it.—Vice is the greatest coward in the world when it knows it will be resolutely opposed; and what have good men engaged in a right cause to fear?"

No wonder, after such an account and such a homily that the listeners exclaim with unreserved amazement, "What an admirable man is Sir Charles Grandison—thus thinking, thus acting!" But why follow him through the remainder of this long apotheosis? We should seek in vain if we expected aught of him but the most consistent and thoroughgoing perfection. It is needless to say that we should conclude him to be (long before we reached the last page) the most unmitigated prig.

Although he would not scruple to draw his sword when there was absolute necessity for it, he differs from the man of action in his very conscientious hesitancy; he differs from the emotional man, in his complete and natural control over his feelings, of which the author constantly assures us he has an abundant supply. In short, his faculties are so nicely adjusted that he can be called nothing else than the balanced character of which Ribot is so doubtful, and which in its masculine form, at least, we seldom or never, meet in real life.

Daniel Deronda[1] and John Halifax[2] may perhaps be intended for balanced characters, but neither of them is particularly attractive. Adam Bede[3] might come under this head also, but he has a certain unpretentious solidity about him which prevents our becoming impatient with him.

Portia[4] is one of the most perfectly balanced feminine characters in literature yet she does not appear tiresome nor impossible as Grandison and Deronda do. Perhaps this is because it does not seem unnatural for a woman to be perfect! Adapting Richardson's description of Sir Charles, we find it fairly applies to Portia: "A woman of religion and virtue; of liveliness and spirit; accomplished and agreeable; happy in herself and a blessing to others."

Lack of space forbids the discussion of the partial characters

1 Daniel Deronda: G. Eliot. 2 John Halifax, Gentleman: D. M. Craik. 3 Adam Bede: G. Eliot. 4 The Merchant of Venice, Shakespeare.

of literature. Many that might be so named would, also, it is safe to say, go as easily into one of the groups of composite characters, according to the predominating element which exhibited itself. A considerable difference of opinion might well be aroused as to the final classification of such partial or composite characters as George Meredith's "Egoist,"[1] or Ibsen's Rebecca West,[2] though such a division of opinion would be neither unnatural nor uninstructive.

As to the abnormal characters in literature, like Falstaff,[3] Don Quixote,[4] Quilp,[5] and others, a volume might be written. Indeed, the task of "pigeon-holing" according to temperaments even the more famous personages in literature becomes upon contemplation, a task so large as to seem little short of presumptuous. The present paper can claim to be nothing more than tentative and suggestive. Much remains to be done, which only the widest possible knowledge of literature and psychology could hope to render at all complete.

[1]The Egoist: G. Meredith. [2]Rosmersholm: Ibsen. [3]King Henry IV; The Merry Wives of Windsor: Shakespeare. [4]Don Quixote: Cervantes. [5]Old Curiosity Shop: Dickens.

THE EFFECT OF VARIOUS KINDS OF ARTIFICIAL ILLUMINATION UPON COLORED SURFACES

By H. E. HOUSTON and W. W. WASHBURN

It is a well known fact, even to the casual observer, that colored surfaces appear of a different color under artificial illumination. Especially is this true of certain blues and greens, which appear as greens and blues when illuminated by the oil lamp.

The object of the present investigation is to measure the change in color which takes place when various colored surfaces are illuminated by the various kinds of artificial illumination now in common use: *e. g.*, oil lamp, gas jet, candle, incandescent and arc electric lamps, and Welsbach burner: all of which are compared with daylight.

The colors to be measured were compared by means of color-wheel mixtures on two concentric color-wheels. A portion of each wheel was illuminated by the lights in question, an area of 2cm. square being blocked off by means of a screen, and diffused light being excluded by means of diaphragms. All kinds of artificial illumination were made equal in intensity to that of daylight, which was reflected from an open window by means of a heliostat. The intensities were made equal by varying the intensity of the artificial light to be compared. This was done by varying the distance of the light from the illuminated surface. An even illumination over the entire colored surface was obtained by sending both lights through ground glass. The intensity, thus obtained, was approximately that of one thousand candles at the distance of one metre. No other intensity of illumination was used.

The colored discs used on the color-wheel were prepared in the following way. Six pigments, viz., English Vermilion, Mineral Orange, Chrome Yellow, Emerald Green (Paris Green), and Artificial Ultramarine, were mixed in gum-arabic and applied to the discs by means of a brush. After this, the paper while yet wet was dusted with the paint powder. We thus obtained very good colors. These colors were then defined by comparing with spectral lines in the following way. A spectroscope was used, in which all but one color was cut off by means of a screen in the observing telescope; we thus avoided contrast effects, and isolated one color line for comparison. This color would change as the observing telescope was moved and the color thus projected could easily be compared with the colored paper held in the hand. Three com-

parisons were made in the case of each color, the averages and average variations being calculated. This must be regarded as only a rough test of hue, and is not meant to refer to the actual light-composition of the stimuli used. A photometric determination of the intensity of these colored discs is given in one of the tables, the method of measurement being that of the flicker photometer. The intensities of illumination were varied by varying the distances of the light from the rotating discs. The standard white of the flicker photometer was then compared in the same way with the intensity of magnesium oxide, and finally all results were reduced to this standard.

The following tables give the value of six colors illuminated by daylight of which the definition is stated in terms of the same color illuminated by artificial light. Thus by substitution it would be possible to find the value of any color by artificial illumination in terms of the same color by daylight with certain additions.

The tables give the averages and average variations, ten measurements being made in each case. Following the tables will be found a diagram showing in a graphic way the changes in wave length of each of the standard colors caused by the use of artificial lights. The average variations are given in parenthesis, and when only two discs were used (the variation being symmetrical) but one variation is given.

INCANDESCENT	ARC
85.7 R + 14.3 B	(1.3) = R
R	(2.0) = 1.92 Orange + 98.08 R
5.72 R + 94.28 Orange	(.76) = Orange
Orange	(1.08) = .99Y + 99.01 Orange
52.4 G + 47.6 Y	(.1) = Y
Y	(.1) = 32.4 Orange + 67.6 Y
44.0 B + 56.0 G	(1.8 B) = 63.9 G + 36.1 Bk. (1.3 G)
66.37 G + 1.94 Y + 31.69 Bk. = G	
(1.07G) (1.2Y) (0.8 Bk.)	
59.46 B + 40.54 G	(1.44) = 31 B + 69 Bk.
96 B + 4 W	(.21 B) = 16.89 B + 3.09 R + 80.02 Bk. (.12 R) (.24 Bk.)

INCANDESCENT	OIL
91.8 R + 8.2 B	(6.2) = R
R	(.9) = 90.1 R + 9.9 Orange

78.3 Orange + 21. 7 R	(.9) = Orange
Orange	(.8) = 95.72 Orange + 4.28 Y
77.4 Y + 22.6 Orange	(.8) = Y
Y	(1.1) = 82.1 Y + 17.9 G
49.9 Y + 50.1 G	(.65) = G
G	(.8) = 73.0 G + 27.0 B
98.96 B + 1.04 R	(1.8) = B
B	(1.4) = 98.98 B + 1.02 G

Incandescent	Gas
99.6 R + 0.4 B	(.13) = R
R	(.22) = 99.5 R + 0.5 Orange
99.5 Orange + 0.5 Y	(.27) = Orange
Orange	(.33) = 99.6 Orange + 0.4 R
94 Y + 6 G	(.15) = Y
Y	(.7) = 95 Y + 5 Orange
91 G + 9 B	(.8) = G
G	(.12) = 98.1 G + 1.9 Yellow
98.1 B + 1.9 G	(.18) = B
B	(.17) = 99.4 B + 0.6 R

Incandescent	Daylight
84 R + 16 White	(1.2) = R
24 White + 76 Orange	(.7) = Orange
43 Y + 57 G	(.9) = Y
Y	(.8) = 36 Y + 64 Orange
45 G + 55 B	(1.5) = (.6) 4 G + 96 Black
G	(.6) = 91 G + 9 Y
95 B + 4 G + 1 W	= 13 B + 87 Bk.
(.4) (.1) (0.8)	= (.6)
B	= 49.2 B + 1.6 R + 49.2 Black
	(1.6) (1.1) (1.56)

Incandescent	Candle
99.2 R + 0.8 Orange	(.28) = R
R	(.29) = 99.3 R + 0.7 B
99.1 Orange + 0.9 R	(.31) = Orange
Orange	(.60) = 97.7 Orange + 2.3 Y

83 Y + 17 Orange	(.16)	= Y
Y	(1.1)	= 20 G + 80 Y
97.9 G + 2.1 Y	(.52)	= G
G	(.73)	= 97.4 G + 2.6 B
98.0 B + 2.0 R	(.64)	= B
B	(.46)	= 98.1 B + 1.9 G

INCANDESCENT		WELSBACH
55 R + 45 Bk.	(1.1)	= R
R		= 54 Orange + 7 Y + 39 Bk (1.2) (0.5) (1.1)
54 Orange + 46 R	(2.0)	= (1.5) 53 Orange + 47 Bk.
Orange	(.10)	= 47 Orange + 53 Y
62 Y + 38 Bk	(1.0)	= (1.1) 54 Y + 46 G
36 Y + 64 G	(1.3)	= 50 G + 47 Bk + 3 White (1.1) (1.1) (.6)
G		= 69 G + 6 Y + 25 Bk. (1.2) (.8) (1.3)
94 B + 6 G	(0.8)	= (1.5) 38 B + 62 Bk
B	(0.5)	= (.5) 93 B + 3 R + 4 Bk. (.2)
84 B + 16 G	(0.4)	= B

Intensity of standards, in terms of standard white used in experiments and of oxide of magnesium :—

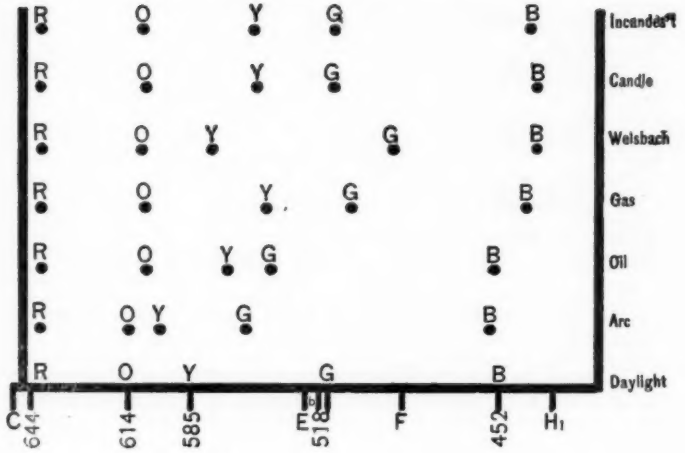
Color	Red	Orange	Yellow	Green	Blue	Black	White
Wave-length	616	604	546	535	447		
Intensity in terms of standard white	28.9	32.0	56.7	17.8	2.9		
Average variation	1.14	2.00	1.56	1.44	0.50		
Intensity in terms of magnesium oxide	26.7	29.4	52.2	16.4	2.7	8.2	92.0 + 1.3

Color-wheel definition of white under arc lamp illumination :—Gray (white) = 16 White + 84 Bk = 14.1 R + 66.1 G + 19.8 B.

CHECK UPON PHOTOMETRY.

Intensity of R + G + B = 26.4 %
" " Bk. + White = 23.5 %

Difference in intensity = 2.9 %


R O Y G B Incandescent
R O Y G B Candle
R O Y G B Welsbach
R O Y G B Gas
R O Y G B Oil
R O Y G B Arc
R O Y G B Daylight
C 644
614
585
E 518
F
452
H1

A BIBLIOGRAPHY OF THE SCIENTIFIC WRITINGS OF WILHELM WUNDT

By E. B. TITCHENER and L. R. GEISSLER

The following list is printed as the beginning of a bibliography of Professor Wundt's scientific and philosophical writings. We hope to continue it in annual installments (the first supplementary list to appear in October, 1909), and we shall be grateful for any corrections and additional items that the readers of the *Journal* may be able to supply.

More than five-sixths of the titles here given have been verified by the one or the other of the compilers. Most of the remainder have been looked up by correspondents; a few have been taken from trade-catalogues and existing bibliographies.[1]

Editor

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(6) *Elemente der Psychophysik*, von GUSTAV THEODOR FECHNER. Dritte unveränderte Auflage. Mit Hinweisen auf des Verfassers spätere Arbeiten and einem chronologisch geordneten Verzeich-

[1] Our thanks are due, in particular, to the Librarian of the Surgeon General's Office, Washington; to Dr. L. N. Wilson, Librarian of Clark University; to Professor R. M. Yerkes and Dr. B. Rand, of Harvard University; to Mr. C. E. Ferree, of Bryn Mawr College; and to Mr. W. H. Austen, Reference Librarian of Cornell University.

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mandato renuntiantur philosophiae doctores et artium liberalium magistri rectore magnifico F. Zarncke decano G. M. Wundt procancellario I. A. H. Leskien inde a die primo mensis novembris a. MDCCCLXXXI usque ad diem ultimum mensis octobris a. MDCCCLXXXII creati. Praemissa est G. Wundtii commentatio patrio sermone conscripta: Das Weber'sche Gesetz und die Methode der Minimaländerungen.]

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MINOR COMMUNICATIONS

ON THE ASSOCIATIVE POWER OF ODORS

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That odors have the power to recall the past with unusual vividness is an observation not infrequently to be met in general literature, and casual experience now and then seems to confirm it. Careful laboratory experiments on the other hand have given no evidence for such a pre-eminence.[1] The mediating fact seems to be that both the observations and the experiments are correct for the special conditions under which they have been made, and both misleading if incautiously generalized. Casual observation here, as usually, is struck by the exceptional and neglects the commonplace; it notes the cases where vivid memories are roused by odors, but fails to observe the vastly more numerous instances in which they suggest nothing old and nothing vivid. The odor of coffee, of kerosene, of illuminating gas, of coal tar, of fresh paint, of tobacco, are to most people no more definitely suggestive of the remote past than the sight of the same articles would be. It is clear, then, that if odors on some occasions give rise to vivid recollections, they must do so in virtue of some peculiarity in the odor or in the circumstances under which it is now or has previously been perceived.

In the writer's belief the essential features (after a suitable apperceptive mood at the time of forming the association and again at its recall) are simply that the odor shall be one that is not too frequently experienced, at least not so frequently experienced under varied conditions, that its preponderant association with one set of circumstances is weakened and blurred out by many others, and, as contributing to this last, an attitude of interest in the odor *per se* and not as merely means to an end.

It is not difficult to find analogous cases. Sense experiences in any field are apt, if they recall anything at all, to call up their circumstances vividly when these are unique and infrequent; but they lose that power when often repeated in many settings. Old tunes recall the past clearly if not heard too often; those heard frequently recall, as a rule, recent circumstances only or none at all. Faces known only in pictures and thus always seen from the same aspect (the common portraits of Washington, for example), are often recalled more definitely than the faces of one's own family which are seen from day to day in a hundred different aspects. In a word, when odors call up the past with definiteness, they probably do so because they are associated with comparatively little else than the circumstances which they recall, and if odors have such limited associations more frequently than sights and sounds, it is because they are less often and

[1] Heywood, Alice, and Vortriede, Helen A.: Some Experiments on the Associative Power of Smells, this *Journal*, XVI, 1905, 537-541; and Bolger and Titchener, this *Journal*, XVIII, 1907, 326-327.

less attentively experienced. They are like ordinary photographs showing one image clearly, while sights and sounds (and "ordinary" odors) are like composite pictures in which so many faces are united that no one is clear above the rest.

The laboratory studies have not taken this feature into view and have therefore not succeeded in reproducing the essential conditions of the phenomenon as it appears casually, though at the same time they have made clear that odors as a class are probably without exceptional reproductive power—except such, perhaps, as may attach to them through their high affective coloration.

The experiments to be described in this paper are, it must be confessed, inadequate to a direct proof of the above hypothesis though they offer considerable indirect evidence for it. The method employed was the very simple one of presenting to the observers a series of odors under conditions which required the formation of certain definite new associations and noting the changes that took place in both the old and new associations as the latter were gradually formed; and later following this up by occasional testings at intervals of from a few days to several weeks and in some cases a number of months. The odors used were twenty-five easily obtainable ones which promised, nevertheless, to be unfamiliar enough not to be instantly named by the observers. No effort was made to select odors representative of the different odor groups of Zwaardemaker, but some of them were agreeable and some disagreeable. The new associations to be formed were with two-place numbers, one for each odor. The odors were placed in small bottles, all alike and all wrapped to the top in exactly the same way with blue paper and all labeled with gummed labels carrying the different numbers in large type.

In making a test the experimenter handed one of the bottles to the observer who uncorked it, took a whiff of the odor and gave its number if he was able (or, in the case of the first presentation, some indication of such associations as were called up by it, if any had appeared). The observer then looked at the number and tried in such manner as he pleased to connect it with the odor, after which he was given another bottle, and so on to the end of the series, when he reported anything with reference to the associations or their formation which he judged worthy of record.

In the earlier experiments the association did not become permanent until after several sittings, because too little attention was given to the number (seen and pronounced but a single time) even when only five bottles were used at a time; the odor, when it came, drove the number completely out of mind. Later when this defect was remedied by concentration of attention upon the number for fifteen or twenty seconds before taking a whiff of the odor a set of five odors could be connected with their numbers at a single sitting, though of course much more practice was required before the number came "direct," that is, came first, and without mediation, to consciousness.

Of the seven observers who served in these experiments two were university men, one a university professor, one a woman physician, one a nurse, one an artist and one a housekeeper. For convenience they will be designated by letter: *A*, *B*, and *F* were men; *C*, *D*, *E*, and *G* were women. Not many tests were made with *G*.

The following introspections reported at the close of the tests from time to time, give some indication as to the behavior of the old or earliest associations. The differences are probably due, as will be shown more fully later, to the mental attitude of the observer toward the whole experiment. The odors at the first sitting called up in *A*'s mind scenes of his childhood and an early apprenticeship in a drug

store; later he remarked that the associations were mainly with previous sittings in the present experiment and that as the odors came "direct" the old associations dropped out and did not even come secondarily; on still another day he spoke of them as being so "far in the background as to have given place entirely to the recent associations." Of somewhat similar tenor were the reports of *C*, the woman physician, who has a very keen sense of smell coupled with a lively visual imagination and has had, of course, daily experience with odors and some reason for attending to them. With this observer the odors at first had both the elements of remote and of recent experience. She used at different times in general introspection the following expressions: "The concrete associations are dropping out but with longer thinking they come back;" "the main associations are with the last time of smelling," the concrete associations are in the fringe of consciousness." At the last time she reported that the old associations were in the periphery of consciousness but staid there through the habit of ignoring them. *C* at first referred nearly all the odors to definite classes in *materia medica*, and the associations with experiences of childhood, though present, were relatively few. She easily became indifferent to the affective coloration of odors that were at first pleasant or the contrary, thus carrying over her professional attitude into a new field. These observations show the attitude that may be acquired toward the associations called up by odors, and at the same time confirm in their measure the hypothesis above propounded that the powerful associative quality of smells is due jointly to the infrequency of their occurrence and to the attitude or purpose with which they are received.

If for any reason the frequent experience of odors leads to the repetition of the old associations rather than the formation of new ones, a strengthening rather than a weakening of the old will naturally result; and something of this kind seems to have taken place with observers *B* and *D*. *B* had great difficulty at first in getting certain of the odors to come "direct" and remarked that the "associations already called up exclude all new ones." After the first three months' interval of no practice *B* said that for him the more ready recall of the number depended rather on the definiteness of the odor [*i. e.* its unlikeliness of confusion with others] than on the recency, yet as the experiment continued the associations were rather with previous sittings than with still earlier experiences. The first associations, had not really dropped out, but came up after the more recent ones.

D's case was even more marked, for she reported an actual reinforcement of the first associations even to the end of the tests. She speaks nevertheless of a little association with other times of testing; and in connection with one odor, smelled again after a long interval, there was a distinct association with a door-bell interruption that had occurred with that odor at an earlier test. The attitude of observer *D* was quite different from that of *C*; her trend of interest was not at all professional but toward the odor itself and what it recalled. The various odors after practice brought their numbers directly indeed, but generally some association with early life or everyday scenes came up also. She did not, like the other observers, have in the tests after the longer intervals, associations with the previous times of learning. The emotional coloring seems to have led, as we have already suggested, to such a repetition and reinforcement of the primary associations as caused their persistence though secondary in point of time. A longer continuance of the practice with the new associations and a practical purpose in forming them would very likely have made them preponderant over the old, even in her case.

F after a five months' interval, on being tested, reported: "Associations in general are very meagre. However, all but one [of twenty odors] seem familiar. . . . . Visual imagery, except in two cases, is not present at all. . . . . There is really much less imagery than when I learned them and [in response to a question] there was not a single case of association now with the times of learning." The introspections of the other observers furnished little evidence on these points.

With reference to the formation of the new associations the experience of all the observers was tolerably uniform and such as one might expect it to be. The differences between the different subjects were mainly quantitative. In most cases the old associations tended in course of time to drop out and leave the name and the number to struggle together. The association of the odor with the number generally went through three distinguishable stages. In the first the name given to the odor, in many cases accompanied by visual imagery, would rise at once on the perception of the odor and be followed immediately by the number. The announcement of the observer in such cases would be, *e. g.*, "Tar—84." Such a stage would continue from 5 or 6 to 15 or 20 days, varying with the observer, the affective quality of the odor, the pitch of attention, the degree of familiarity, the general attitude of the observer, etc.

The transition from this first stage to the second was a gradual weakening or recession of the name, and a gain in certainty and promptness in the number.[1] In many instances, though not in the case of all associations that attained "directness," there came after the first a clearly marked, but often short, second stage when the word and the number seemed to rise together. This "simultaneous" phase did not often last more than one or two days, but there was more or less tendency to relapse into it when "directness" had been attained but not fully established. In the first stage there was often some discouragement, and such statements as "I believe these will never come 'direct'" were not unusual. When the "simultaneous" stage came there was a feeling of encouragement or success which seemed to hasten progress. In the third and last stage the association with the number was prompt and without mediation. The observer's announcement was: "84—tar." With practice the name retired still further into the background, coming later and later, until it finally ceased to appear, and the odor called up the number only.[2]

After intervals of rest of a week or more, and in the earlier stages even after the interval from Saturday to Monday, the new associations seemed noticeably weakened. *A*, for example, after an interval of ten days, when most of the numbers were nearly "direct", thought that all associations with the numbers had become a little uncertain as compared with what they were before. In at least two other instances, however, number associations once established showed great "directness" and persistence. *B* reported that several months after his last test he happened one day to get an odor to which he at once said only "76," and no old name followed. At about the same time *E*, fully two months after her last test, found spearmint growing wild. She caught the odor and at once said "63." In these we have apparently

[1] *A* remarked at an early stage that if for any reason the name was hindered in rising the number stood ready.

[2] Complete unfamiliarity in the odor favored the prompt association of it with its number. To *E* number 41 was so unfamiliar that she had no other name or association with it and hence the number 41 served itself as a name and became almost immediately "direct."

chance cases on a small scale of the same "unusual" reproductive power of odors which we are endeavoring to explain.[1]

With certain subjects a prominent factor in the learning of the numbers was the formation of mnemonics, for example, "63, three, tree, herb, mint." While of some advantage in the first fixing of the numbers, these often seemed to hinder in the "coming direct," the mnemonic links being especially persistent. Others made use of incidental helps. *C*, for example, was inclined to set the odor in its place in the series as given at the first test. *A* had also a similar tendency, and when two groups of five were thrown together he confused the two that had been originally at the middle of the separate groups. He also noted other general confusions from running two groups together. *B* also, after he had had two or three different series of five, would fumble considerably at the beginning of any test if he had not been told that the first, second or third series was to be used. Two or three mistakes might be made (imaginations of other series) until the proper set of associations was brought into play by some odor more distinct than the rest. *F* presented the unusual but interesting ability to give the approximate numerical location of any odor in the entire series, at the same time showing considerable difficulty in getting the numbers exactly, saying, for example, "Well, that's in the fifties," or "that's up near the nineties." He could not give any definite introspection as to his manner of locating them, but it seems to point to some sort of number-form, influential though far in the periphery of consciousness. *A* also, who has a definite number-form, had something of the same power of approximate location.

The affective qualities of the odors seem to have played a certain subordinate role in the fixing of the associations, some distinctly pleasant (and in a few instances some distinctly unpleasant) having formed especially prompt and lasting associations with their numbers; but our evidence on this matter is meagre. Certain remarks of the observers suggest, also, another and closer point of connection of affective qualities with our main question. Odors, as a rule, carry a strong affective coloration, but this is weakened and in some cases nearly disappears with frequent experience of them. With *C*, it was noted as has been said that the feeling element seemed to fall away as testing with the odors was continued. It also returned again in a measure after about a month's interval of no work with them, as was observed on two separate occasions. It would seem, therefore, that the feeling coloration of the odors and their tendency to recall early associations run a somewhat parallel course, which next suggests the question whether the feeling is not itself an important link in the recall. The data furnished by the present experiment throw no further light upon the matter, but an affirmative answer would seem not unlikely.

[1] Observer *C* showed the interesting case of two odors the numbers for which had not yet become established as "direct," but nevertheless rose without intermediary after a six weeks' interval.

MYSELF AND I: A CONFESSION

By L. G. Winston

Somewhat after the order of Dr. Jekyl and Mr. Hyde I seem to possess two distinct personalities, being both at the same time but presenting no such striking contrast as the Jekyl-Hyde combination. They are about equally virtuous. Their main difference seems to be one of age, one being a decade or so in advance of the other.

At times they work harmoniously together and again at cross purposes. I do not seem to have developed equally. Part of me sits humbly at the feet of the other part of me and receives advice and instruction. Part of me feels constrained to confess to the other part of me when it has done wrong and meekly receives rebuke. Part of me tries to shock the other part of me and to force the more dignified part to misbehave and giggle and do things not considered correct in polite society.

My younger part delights to tease the older, to doubt her motives, to interrupt her meditations. It wants to play while my older self is more seriously inclined. My younger self is only twelve years old. This is my real self. To my own mind I am still a little girl with short dresses and a bunch of curls. For some reason my idea of self has never advanced beyond this point. The long dress and the hair piled high will never seem natural. Sometimes I enjoy this duality and again I do not. Sometimes the two parts mingle delightfully together, again they wrangle atrociously, while I (there seems to be a third part of me) sit off and watch the outcome.

The older part gets tired before the younger. The younger still fresh and in a good humor undertakes to furnish amusement for the older. I have often thrown myself on the bed wearied and exhausted and been made to shake with laughter at the capers of the younger part of me. They are capers indeed. On these occasions she will carry on conversations with friends—real friends—fairly bristling with witticisms, and although taking both parts herself, the parry and thrust is delightful.

Sometimes, however, the younger part of me seems to get up all awry. She will carry on quarrels—heated quarrels—from morning till night, taking both sides herself, with persons whom I (the combination) dearly love, and against whom I have no grievance whatever. These are a great distress to my older self.

On other days she seems to take the greatest delight in torturing me with imaginary horrors. She cuts my throat, pulls my eyes out of their sockets, removes tumors and amputates limbs until I wonder that there is anything left of me. She does it all without administering anæsthetics and seems to enjoy my horror and disgust.

Again some little jingle or tune will take her fancy—and she will repeat it to herself until I am almost driven to madness. Sometimes it is only a word, but it seems to have a fascination for her and she rolls it as a sweet morsel under her tongue until sleep puts an end to it.

Again, if I (the combination) fall ill, one part of me, I have never discovered which, invariably hints that I am not ill at all but merely

pretending. So much so that it has become with me a recognized symptom of incipient illness.

Moreover, the younger and older are never on the same side of any question. One leans to wisdom, the other to fun. I am a house divided against itself. The younger longs to dance, to go to the theatre and to play cards, all of which the older disapproves. The younger mocks the older, calls her hypocrite and the like until the older well-nigh believes it herself and almost yields to her pleadings. The older listens sedately to the sermon, while the younger plans her Easter suit or makes fun of the preacher.

The older declares she will never marry, while the younger scouts the idea of being an old maid. But even if she could gain the consent of the older it were but little better, they differ so as to their ideals.

In society the difference is more marked. I seem to be a combination chaperone and protege. The older appears at ease, the younger shy and awkward, she has never made her debut. If one addresses a remark to her she is thrown into utter confusion until the older rushes to the rescue. My sympathy is with the younger, however, for even to this day I, the combination, can scarce resist the temptation to say nothing when there is nothing to say.

There is something tragic to me in this Siamese twins arrangement of two so uncongenial. I am at one and the same time, pupil and teacher, offender and judge, performer and critic, chaperone and protege, a prim, precise, old maid and a rollicking school girl, a Tomboy and prude, a saint and sinner. What can result from such a combination? That we get on tolerably is a wonder. Some days, however, we get on admirably together, part of me paying compliments to the other part of me—whole days being given to this—until each of us has such a good opinion of herself and the other that we feel on equal terms and are at our happiest.

But how dreadful are the days when we turn against each other! There are not words enough to express the contempt which we feel for ourselves. We seem to set each other in the corner and the combination as a whole is utterly miserable.

I can but wonder and enjoy and wait to see what Myself and I will make of Me.

PSYCHOLOGICAL LITERATURE

Grundlinien der Psychologie, von DR. STEPHAN WITASEK. Mit 15 Figuren im Text. (Philosophische Bibliothek, Band 115.) Leipzig, Verlag der Dürr'schen Buchhandlung, 1908. pp. viii, 392. Mk. 3.00.

This little volume has a twofold claim to consideration: first, as a text-book for class instruction, written by one of the best known and most competent of the younger generation of psychologists, and secondly as a summary of the views held by that Austrian school of which Höfler and Meinong are the leaders. To the present reviewer, the latter claim appears definitely to outweigh the former. We do not doubt that the book could be used with success, in undergraduate work, by its author or by a teacher of like training; and we have nothing but admiration for many of its features—its resolute facing of difficulties, its solid packing of fact, its caution and suspension of judgment on various disputed points. But we find, on the other hand, a marked unevenness of style, ranging from the colloquial simplicity of the primer to argumentation on the highest technical level; we find that the ideal of complete exposition, praiseworthy in itself, has too often led to the dryness and heaviness of an encyclopædia article; and we find ourselves compelled, as the book proceeds, to master a highly articulated terminology, which is not applied in such detail or with such frequency as to become wholly familiar, and which must therefore tend to substitute, in the beginner's mind, a psychology of reflection for the psychology of observation. In these respects the book is distinctly inferior to Ebbinghaus's *Abriss*. It is mainly interesting, then, as a compendious statement of the current psychology of the Austrian school. Höfler's *Psychologie* and *Grundlehren der Psychologie* appeared as long ago as 1897; and although the general attitude of the school has remained unchanged, the progress of psychology during the last eleven years has naturally served to extend, modify, revise and clarify its fundamental ideas. In this work of systematization, the author of the *Grundlinien* has himself played an active part.

The book has two main divisions: a shorter, entitled General Psychology, which occupies 96 pp., and a longer, Special Psychology, which occupies 270 pp. Ch. i of the former division defines the province of the science. The subject-matter of psychology is the sum-total of mental facts; and the characteristic feature of anything 'mental' is that it points beyond itself to a 'physical.' "Unser Vorstellen ist so beschaffen, dass es uns *Dinge* zur Vorstellung bringt:" "mein Denken erfasst Dinge, die selbst kein Denken, ja überhaupt nichts Geistiges sind. . . . Das Gleiche gilt vom Fühlen und vom Wollen." This 'pointing to' is the most obvious indication of that essential difference between the two realms of fact of which one can, in the last resort, say nothing more than: "Materielles hier und dort Geistiges." Its explanation is relegable to epistemology. So much on the positive side. On the negative, the author rejects both the older definitions of psychology as the 'science of mind' and the more recent definition which makes it the 'science of the subjective aspects (properties, attributes) of experience' (Mach, Ebbinghaus, Külpe).

Ch. ii discusses the theories of the relation between mind and body.

The author writes carefully and with reserve, though his leaning towards interactionism is sufficiently clear; psychophysical parallelism, we are told, must, if consistently carried out, lead to the acceptance of a 'substantielle Seele' (p. 40). But it might, on the writer's own principles, just as well lead to a non-substantial 'unconscious;' and its representatives deny emphatically that it leads them either to the one or to the other. The chapter as a whole, while it achieves a difficult task of condensed writing, is far above the level of a brief text-book and far too scrappy for a first-hand discussion.

Ch. iii deals with the concepts of mind, self or ego, and unconscious. From the psychological standpoint, there is no ground for the assumption of a 'substantial mind,' unless we adopt the principle of parallelism; in that case, we must have recourse to a mind-substance, which, however, is not simple but compound (*zusammengesetzt*). The further question of an 'ultimate' simple mind belongs to metaphysics. The psychological self or ego comprises the sum-total of the individual's 'actual' mental facts, and the sum-total of his *Dispositionsgrundlagen*, of the substrata of his mental dispositions. Mental dispositions are not 'unconscious' mental facts; they are, as such, simply faculties or capacities; the only 'real' things that belong to them are constituents of the organism that co-operate, as relatively permanent part-causes, in the realization of the mental activities of the individual. These 'constituents of the organism,' *Dispositionsgrundlagen*, are most naturally regarded by interactionism as physical (cerebral), while parallelism, as has been remarked, must look upon them as mental (manifestations of the mind-substance). 'Unconscious' mental facts are actual, but of such low intensity that they cannot be noticed (*bemerkt*); there is no need for any other interpretation of the term.

Ch. iv undertakes a preliminary classification of the subject matter of psychology. We have to distinguish: first, between the fundamental mental formations (*Gebilde*) and the mental processes (*Prozesse*). The formations fall into two great groups: the intellectual and the emotional. In the former class we find ideas and thoughts; in the latter, feelings and appetitions. But further: we must distinguish, in every fundamental formation, "zum mindesten in gewissem Sinne," between act and content. Thus there is a certain 'part' of the idea by virtue of which it brings a definite object to consciousness; this is its content. There is also a part in virtue of which we recognize it as idea, in contradistinction (say) to feeling, or in virtue of which we mark off idea of perception from idea of memory or of imagination; this is its act. Content and act are, in the idea, inseparable, and both alike are mental; they are thus both different from the 'object' of the idea, which is usually physical.

So far the author. And here the reviewer must interpose his objection to the separation of 'act' and 'content,' as at once unnecessary and confusing. Other psychological systems, as is well known, get on without any such dichotomy of the mental life; and it does not appear that Dr. Witasek gains by its introduction. He writes, as always, carefully; doubtless with especial care, in view of criticism past and to come. But his exposition, nevertheless, comes perilously near to self-contradiction. Every fundamental formation is ideally separable into act and content, "at least in a certain sense." In what sense? Turn to the special psychology of feeling, p. 318. Here feeling proper, *das Gefühlsmoment* in the affective complex, is all act; quality and intensity of feeling are quality and intensity of act, not of content; the content of feeling is not affective content at all, but ideational content. Or turn to the special psychology of thought, p. 280. Judgment divides ideally into act of judgment and content of

judgment. The act has two essential moments, conviction and affirmation-negation. The content of the judgment is not judgment-content, any more than the content of feeling is feeling-content; it is, again, ideational content. But there is a further complication. The 'contact' of ideational content with the affirmation-negation moment of the act brings into being a new quasi-content, the objective. This objective is not subject-matter for psychology; it is, however, psychologically useful as indicating the way in which the act of judgment approaches and connects with the (ideational) content of judgment; thus, we distinguish by its means between the thetic and the synthetic function of the act of judgment, the behavior of the act in the existential and categorical judgments of the logic text-books. For the rest, the conviction-moment of the act is capable only of intensive gradation; the moment of affirmation-negation is qualitative in character. Between the qualitative extremes lie qualitative transitional forms, the middlemost of which is a suspense of judgment (p. 285); it is, however, not clear to the reviewer whether these intermediate qualities belong purely to the moment of affirmation-negation or represent combinations of this with the moment of conviction (pp. 79, 283 f.). Further: certain judgments (not all) evince in the act of judgment a third moment or attribute, that of evidence. This may appear as evidence of (objective) certainty, correlated with affirmation or negation; or as evidence of (objective) probability, correlated with the qualitative transition forms of that moment; whether evidence itself is quantitatively or qualitatively graded is not expressly said, but the gradation would seem to be qualitative.

The underlying idea of all this classification may be simply expressed in the sentence: 'mental facts' point beyond themselves (1) in various ways (2) to different things. The ways come to consciousness as act, the things as content. But a first point of criticism, which at once suggests itself, is that the typical function of pointing-towards is exercised only by the idea; the idea is assumed to be the typical mental formation. At the beginning of the book, mental fact is defined by reference to idea, and the other varieties of mental formation are listed, so to say, as an appendix (pp. 6 f.). When the distinction of act and content is first drawn (pp. 73 ff.), we are left 'doubtful' whether the content of feeling, wish, etc., is directly or indirectly given; given, that is, as object-brought-to-consciousness by the pointing of feeling-act to object of feeling, or given secondarily, as object-already-brought-to-consciousness-by-act-of-idea. When we come to the special psychology of feeling and judgment, the doubt has disappeared; the content is ready-made ideational content, and the acts of feeling and of thought do not aim directly at objects at all. In other words, the original definition of 'mental fact' has, in the writer's own exposition and quite apart from any further question of its validity, been modified to meet the cases of feeling and judgment; or, to invert this statement, the treatment of feeling and judgment has been forced into the terms of a definition which is inadequate to them. A second point of criticism is suggested by the definition of act. The act of idea or judgment (p. 75) is that part or aspect of the formation which is directed towards the object; it is a 'relation' or a 'reference' in the idea of judgment. Now references may be qualitatively dissimilar; but can they differ intensively? Can there be more and less of a particular manner-of-pointing? If the reply is made that such a state of affairs, while logically impossible, is possible in psychology, then we are brought face to face with the real issue involved in the whole classification, the ultimate question of psychological fact. Does introspection compel us to separate act from content, whether in the idea or elsewhere?

And is Dr. Witasek photographing consciousness or imaginatively constructing it? Does he offer us *Beschreibung* or *Kundgabe*, *Erlebnis* or *Ausdruck?* In the reviewer's opinion, his act-and-content psychology is the artificial product of a wrong initial attitude: the attitude of one who is not content to regard mind as a datum for scientific description and explanation, but who reads his epistemology at every point into his psychology.

To return, however, to Ch. iv. The mental 'processes' come to consciousness as sequences, continuous or discrete, of fundamental mental formations. They may be classified, empirically, by reference to the act (of idea, of thought, of feeling, of appetition) with which they begin and end. Thus, if the process runs from idea to idea we have 'association;' with other first and last terms we have rumination, comparison, integration, attention, inference, vacillation, deliberation, resolution, etc., etc. It is, however, characteristic of all such processes that they are not adequately defined by reference to consciousness; their essentials lie outside consciousness, in the brain (interactionism) or in the unconscious depths of the substantial mind (parallelism). Further: since the mental formations themselves depend in part upon extra-conscious conditions, and since these conditions are most plausibly identified with the extra-conscious essentials of the mental processes, we may consider idea, thought, feeling and appetition, from the point of view of process, as ideation, thinking, being-affected, desiring. This reading of formation as process gives us a definite point of attack for our process-psychology; beginning with the formation process, we may gradually advance to a theory of the processes *sensu stricto*. In the meantime, we note that processes obviously divide into active and passive, and that the active tend (in course of practice) to lapse into passive; so that the same mental result may represent very different expenditures of mental force; or very different amounts of mental work.

Besides formations and processes, psychology has to take account of mental dispositions. These, as we have noted, are not themselves in any sense real things. They are *Kausalrelationsfälle;* they express the fact that the individual contains within him a part-cause of his mental processes and formations. The two principle problems of this division of psychology are, first, that of the number of fundamental dispositions (whether, *e. g.*, memory and imagination are, as dispositions, identical or different), and secondly that of dispositional change (practice, fatigue, etc.; change by acquisition of new dispositions).

Ch. v, the concluding chapter of the division of General Psychology, deals with the problem and method of psychology. As we find here nothing new or characteristic, we may pass directly to a few concluding remarks upon the division of Special Psychology. Here we have four chapters, named from the four fundamental formations, idea, thought, feeling and appetition; there are no special chapters devoted to the processes and dispositions. Of the 270 pp. which are assigned to the division, 182 fall to the lot of idea (sensation, 'produced' idea or *Gestaltqualität*, memory and association), 36 to thought, 34 to feeling, and 18 to appetition. The dominance of idea is natural, since experimental psychology has gathered a vast store of facts concerning sensation and memory; we have seen that it is also, from the author's standpoint, justifiable,—idea being the typical 'mental fact.' Thought, on the other hand, is somewhat shabbily treated. And when we note that attention receives hardly nine pages, while the *Annahme* gets five and a half, we are tempted to accept the challenge of the Preface, and to judge the book not only by what it contains, but also by what it omits. The final chapters, on feeling and appetition, are written with

the critical caution to which we have grown accustomed. Nevertheless, more might surely have been made of the appetition; and the average reader would probably be glad to exchange many pages of tentative articulation for a frank and clear statement of opinion.

This whole division makes, in fact, a mixed impression. The careful advance of the close-packed paragraphs is, in its way, admirable. Yet our intellectual palate is not satisfied; we want something more,—that solid and conclusive something, perhaps, which Dr. Witasek denies us, on grounds of general scientific validity, in the brief *Schlusswort*. But it may be that we should have been content with a couple of special chapters on the processes and the dispositions. The discussion of these topics is scattered here and there throughout the four chapters, and not even the unusually good index makes any attempt to round them up; under *psychische Prozesse, e. g.*, there is no reference either to *Aufmerksamkeit* or to *Produktion der Vorstellungen*, under *Disposition* there is no reference to *Reproduktionsdisposition*. The result is that we have no unitary attempt at the solution of problems which the author emphasized as of high importance in ch. iv.

P. E. WINTER.

Vorlesungen zur Einfürung in die experimentelle Pädagogik und ihre psychologische Grundlagen, von ERNST MEUMANN, 2 vols., Leipzig, Engelmann, 1907. pp. 555, 467.

The psycho-pedagogical movement, which dates back about two decades, and which is known in America as "child-study," has been crystallizing in Germany, within the last few years, into the systematic form characteristic of German scholarship, under the double name of Child-psychology, and Experimental Pedagogy. Experimental Pedagogy is child study on a higher plane of scientific development, or perhaps one should say, narrowed down into a more or less exact science, showing its distinctive feature in the application of the methods of experimental psychology to the problems of education and instruction. The investigations in the field had been casual and fragmentary, until the "Experimental Didactics" of Lay appeared in 1903, the first attempt to bring the results of various experimental studies together into a coherent form, and to build upon them a system of scientific pedagogy. Now we have a second work in a similar line, though of somewhat different character, in the "Introduction to Experimental Pedagogy and its Psychological Foundations," by Prof. Meumann.

The book consists of a series of lectures given originally before the Teachers' Union at Kœnigsberg, revised and supplemented for the present publication. The author does not pretend to present a completed system of pedagogy nor even a comprehensive and exhaustive survey of all that has been done in the field of Experimental Pedagogy, but intends, rather, to show, in a popular and brief form, the methods employed in the experimental investigation of pedagogical and didactic problems with illustrations of some of the results already attained. In the course of his lectures, however, he steps out, quite naturally, from these limitations and often seems inclined to speak the final word upon practical questions.

His intellectualistic and formalistic standpoint sound the keynote of the whole book, as the voluntaristic and motoristic philosophy gave that of Lay's "Experimental Didactics." Meumann's work is, however, far less overtly philosophical and his own pedagogic views are much less explicitly asserted than those of Lay.

In the first chapter are discussed the character, problems, peculiar position, and methods of experimental pedagogy, which is defined as experimental investigation in the field of education, and aims at the

final, or, rather, progressive, establishment of a "scientific pedagogy" by means of "systematic observation and experiments." The lengthy defence of systematic observation and experimental methods here made seems to us superfluous; but was very likely appropriate to the audience to which these lectures were originally delivered, and is, at any rate, not unusual in German scholarship. The second chapter is devoted to a general view of the topics which the writer is to treat in the rest of his book. The third chapter treats the physical and mental development of the child, in its general course, characteristics and periodical fluctuations, with the pedagogical bearings of these. In the next four chapters the author goes into the discussion of the development of particular mental faculties, making a comparison between those of the child and the adult. Attention, sense-perception, the perception of space and time, the ideational content of children's minds at their entrance into the school, the development of memory power, representation processes, the development of speech, the growth of the emotional and volitional life—all these receive more or less full treatment. The eighth, ninth and tenth chapters are given to the question of individual differences and types, and close the first volume of the work.

The eleventh chapter, beginning Vol. II, is concerned with scientific methods of mental work and acquisition, its economy, technique and hygiene. The next chapter, as a continuation of the preceding one, is devoted entirely to the study of fatigue. With the thirteenth chapter the author enters upon the problems of special didactics, devoting one chapter to each of the following branches of elementary instruction: Object lessons, reading, writing, number work and drawing. Here he merely shows what can be done in these lines by means of experimental investigation. In the eighteenth, the concluding chapter, he turns to the future of experimental didactics, showing the possibility of the extension of experimental investigation to the higher branches of school study.

The book is written in a clear style, and furnishes easy and agreeable reading, although too minute analysis and not infrequent repetitions are something of a blemish. Its strength lies in the fact that Meumann, as one of the most eminent and vigorous investigators in the field, supplements the results of previous studies with those of researches made by himself or under his immediate direction. Psychologists, as well as experimental pedagogists, might have wished a more detailed account of some of these individual studies, the results of which he publishes here for the first time. Beginners in experimental pedagogy, for whom the book is intended, will, however, find in it an excellent guide to the nature, and the present attainment of this new branch of pedagogy. In fact this is the only book of its kind as yet published. The student of psychology will find those chapters of most interest, in which Meumann treats of memory, attention, association and individual types. T. MISAWA

The Psychology of Feeling and Attention, by EDWARD BRADFORD TITCHENER. The Macmillan Co., New York, 1908. 404 p.

This book consists of eight lectures delivered at Columbia in February, 1908, together with many appended notes. The topics are: 1. Sensation and its attributes; 2. Sensation and affection, the criteria of affection; 3. The affections as *Gefühlsempfindungen;* 4. The tri-dimensional theory of feeling; 5. Attention as sensory clearness; 6 and 7. The laws of attention; 8. Affection and attention. There are some seventy-five pages of notes on various lectures. It is entirely impossible to do justice to a work of this kind in a brief review. It bristles with technicalities and abounds with quotations in French

and German; and more or less of the discussion pertains to matters of method. The most constructive part of the book (pp. 291-3) is the statement of the theory that the material of consciousness or the stuff out of which mind is made is ultimately homogeneous. The affections are of the same general sort as sensations, only they are not developed into them. The affections might thus be called undeveloped sensations but for a verbal difficulty. The peripheral organs of feeling are the free afferent nerve-endings distributed among the inner organs of the body, and these endings represent a lower level of development than the specialized receptive organs. "Had mental development been carried further, pleasantness and unpleasantness might have become sensations; in all likelihood would have been differentiated, each of them, into a large number of sensations. Had our physical development been carried further we might have had a corresponding increase in the number of internal sense-organs." This explains the obscurity of feeling. Affective processes are those whose development has been arrested. The feelings never report the tone of the bodily system from which they proceed and can only vary between the terms good and bad. These reports vary in degree but cannot in kind. And, finally, this theory explains the introspective resemblance between affections and organic sensations. (This note will not preclude longer or more adequate review later.)

Notes on the Development of a Child; II. The Development of the Senses in the first Three Years of Childhood, by MILICENT WASHBURN SHINN. University Press, Berkeley, July, 1907. 258 p. (Univ. of Cal. Pub.)

This long delayed publication is most welcome to those interested in this department of work. It shows that the author's observations and her inferences therefrom and also her reading upon these subjects have been no less careful than upon the topics upon which she has previously published. As an observer Miss Shinn is past master. One cannot, however, but wish that her reading and thought in the line of comparing what others have written upon the subject were a little more developed. As it is, her work is a contribution of really more original acumen, diligence, and scientific value than Preyer's, but after all the work that has been done there ought to be certain, at least tentative, conclusions drawn and at least provisional summaries of results up to date, with perhaps definite statements of problems next in order. The absence of this we consider the chief weakness in Miss Shinn's paper.

Social Psychology—An Outline and Source Book, by EDWARD ALSWORTH ROSS. Macmillan Co., New York, 1908. 366 p.

In this book, extensive rather than intensive, the author first treats of the nature of social psychology; then suggestibility, its relations to sex, politics, public opinion; then crowds (the individual wilts and thought is arrested), the Kentucky revival, non-morality of crowds; comparison of city and country. In the chapter on the mob mind, crazes and fads, children's crusade, Milan's women's crusade, Mrs. Nation, stampede, financial crazes, are discussed. Prophylactics must make us crank-proof. Sane teachers and the classics, avoidance of sensational newspapers, country life, familism, ownership, pride, love, avoidance of yellow religion, are sanative. Then follow chapters on fashions, nature of conventionality in which effects of caste are discussed, snobbery, stigma on toil, the spirit of the age, why it is unwomanly for women to use stimulants, etc. In the eighth chapter the laws of conventional imitation are discussed along with the flagellants, dancing mania, jumpers, spread of disease, drunks, sex

inflammability, contagiousness of ideas, Tarde's law, the Americanization of Porto Ricans, late marriages, child emancipation, aristocracies, power-holders, pace-setters, dollarocracy, barbarizing influences of the smart set, high potential of the city, spread of ideas of equality, custom, historic continuity, Western spirit, etiquette or sway of custom in ancestor worship, social isolation, sedentary life, anarchism, schools and movements in philosophy, art, the curative power of free discussion and polemics, results of conflict, union, deadlocks, compromises, feuds, the relations between public opinion and social tradition, why an equilibrium is not reached.

The Mental Recreations of the Mental Nurse, by R. JONES, M. D. The Journal of Mental Science, July, 1908.

Dr. Jones pleads for periods of complete change of thought for mental nurses. There should be pensions and several weeks annually for vacation, with at least weekly outings through the year, because recently nursing has become far more exacting and involves more risks, troubles, and anxieties. The required training is longer, the degree of efficiency higher. There ought to be physical and also mental recreations, *e. g.*, golf and bridge. The nurse must keep up hope, for her buoyancy sustains the patient. Reading aloud is an important art, and there are nurses' reading circles, presses and a syllabus. Musical culture, interest in pictures upon the wall, healthful ideas generally, the cultivation of the kodak, and perhaps, especially, a thorough religious spirit. All these are important.

Manual of Psychiatry, by J. ROGUES DE FURSAC. Translated by A. J. Rosanoff. Second American from second French edition, revised and enlarged. John Wiley & Son, N. Y., 1908. 406 p.

This writer is very friendly to the new classification of mental diseases introduced by Kraepelin. Most cases indeed, when carefully examined, can be assigned to some of his groups, although of course there are difficulties. The first part treats of general psychiatry, with chapters on etiology, symptomatology, and the practice of psychiatry; while the second part deals with special psychiatry—deliria of infectious origin, psychoses of exhaustion, acute alcoholic intoxication, chronic alcoholism, chronic intoxication by the alkaloids, psychosis of auto-intoxication, acute and subacute thyrogenic psychosis, dementia præcox, chronic delusional insanity, general paresis, disorders due to organic cerebral affections, psychosis of involution, manic-depressive insanity of various types, reasoning insanity (Kraepelin's paranoia), and constitutional psychopathies or mental disorders of epilepsy and of hysteria, and arrests of mental development. The work certainly has the advantage of being brief and lucid.

The Borderland of Epilepsy, by WILLIAM R. GOWERS. P. Blakiston's Sons & Co., Philadelphia, 1907. 118 p. (Lectures on Diseases of the Nervous System, 3rd Series.)

The author has for years kept a special list of all his border-land cases that were near epilepsy but not of it, and he here presents a collective and more or less systematic study of these cases. The symptoms are fainting, syncope, vagal and vaso-vagal attacks, tetanoid spasms, sudden vertigo often involving loss of sight, consciousness, and sense of impulsion, attacks during sleep, pseud-aural border-line epilepsy. He gives a whole chapter to migraine—its alternations, premonitory symptoms, isolated, prodromic symptoms, during pain, somnolence, elaborate premonitory symptoms, night terrors, somnambulism, half-waking states and narcolepsy. These matters are discussed with the author's characteristic good sense and judgment.

Der Tod aus Altersschwäche, von HUGO RIBBERT. Friedrich Cohen, Bonn, 1908. 85 p.

Death from old age is a result of anatomic and functional changes in the composition of the body due especially to the high differentiation of the intercellular substances. It is a necessary result of chemico-physical properties that underlie life. Death from old age is a totally distinct thing from that by disease and is often unaffected by it, although scelerosis may accelerate it and other diseases may bring complications. Natural death is the death of the brain; a high degree of atrophy of the ganglion cells cannot be harmonized with life. Normally all men live approximately the same time, and the variations are what are to be accounted for.

Der Selbstmord als Spekulation des modernen Verbrechertums, von FRANZ CHYLE. Huber & Lahme, Vienna, 1908. 31 p.

The only cure the author sees against the growing tendency to suicide is the reform of family life, especially in the field of feeling and sentiment rather than of the understanding. There can be no doubt that in many respects civilized man is now beginning to degenerate, and that civilization is taking on certain morbid traits. It is fatal to expect too much of life, to be born rich or to be overloaded with culture too early. Suicides have often cursed their parents, holding them responsible for their deeds.

Untersuchungen zur Kenntnis der psychomotorischen Bewegungestörungen bei Geisteskranken, von KARL KLEIST. Werner Klinkhardt, Leipzig, 1908. 171 p.

This is a very valuable study based largely on one case, which seemed to pass through three akinetic stages, involving apraxia and mutism. The author thinks that psycho-motor disturbances are due to troubles of innervation, and is bold enough to do justice to this now too often discarded idea. The third part takes up the psychic conditions of psycho-motor disturbances in organic sensations, association, attention, etc. The writer is a disciple of Wernicke's and emphasizes his consciousness of corporeity, the substratum of which is a reflex system, including muscular and vestibular sensations, with their correlative motor reactions. Psychological investigation points to the same brain areas as does the analysis of motor disturbances. The frontal regions of the brain are focal for the body sense. The author holds to the dependence of psycho-motor symptoms upon effort, fatigue and other organic sensations, as well as feelings and attention.

Unverbesserliche Verbrecher und ihre Behandlung, von SHIGEMA OBA. Hermann Bahr, Berlin, 1908. 84 p.

The chief plea of this writer is that penalty should be proportional to the guilt and must be in the same field in which the crime was committed. Crimes involving pain should be punished with pain; simple theft by fines, according to the heinousness of the deed. He would also have what he calls preliminary punishments, and thus those under possible sentence should be held to a higher degree of accountability. Warnings and threats this writer thinks, therefore, are of great importance.

Sexuelle Ethik, von AUGUST FOREL. Ernst Reinhardt, Munich, n. d. 56 p.

This is a lecture originally given in Munich in 1906, which has reached a circulation of thirty thousand. In this last edition, the author has appended a number of concrete cases, from his experience, ethical-sexual conflicts, that have come to him. There are, for in-

stance, cases of morbid jealousy, of drunkenness and love, of a man who must either refrain from marrying the girl he loved or give up his place in the army, cases of notomanie, of growing discord and incompatibility in married life, of diseased men who wish to marry, of urnings, impotence, nymphomania, hypochondria, satyriasis, hereditary tendencies to disease (whether such should marry), fetishism, effects of reading very plain literature like this lecture, etc. The author's general law, which he urges at the end, is that the sexual nature should neither directly nor indirectly injure any one either of the present or the coming generation.

Geschichte der Philosophie, von MATTHIAS HAMMA. Theissingschen Buchhandlung, Münster, i. W., 1908. 83 p.

This is the tiniest general history of philosophy known to the writer of this review. It ends with Hegel and his immediate followers, and the first edition was issued in 1876; and the second, thirty-two years later, is not much changed. It begins with Thales and includes Schopenhauer and Herbart. It ought to be translated.

Bestia sum: Einige Kapitel über die Kehrseite des Menschtums, von WILHELM WACHTER. Emil Felber, Berlin, 1908. 261 p.

This rather startling title is perhaps quite justified. The author first describes man in primeval times generally, then follows an elaborate chapter on the murder of children among the lower races, and another on cannibalism. In a very striking final chapter, the author draws contrasts and similarities between primitive and civilized man, that are unique and somewhat startling.

Insomnia and Nerve Strain, by HENRY S. UPSON. G. P. Putnam's Sons, New York and London, 1908. 142 p.

The author first gives illustrative cases; then the effects of sleeplessness and fatigue upon the emotions, reflexes, sub-consciousness, atavistic symptoms, inhibition, convulsive seizure and choreic spasm, vascular potential, nutrition, vitality, epicritic neuro-psychoses, with a concluding chapter on prognosis, therapy, predisposition and heredity.

Contribution á la pathologie des mystiques, anamnèse de quatre cas, by FRANCOIS DA COSTA GUIMARAES. Jules Rousset, Paris, 1908. 51 p.

This is an interesting study of four cases of pathological mysticism, chosen and described from the literature, viz.: Plotinus, Fra Angelico, Susanne Labrosse (d. Paris, 1821, age 64), and Eustelle Harpain (d. 1842, age 28). The author's treatment of these cases is rather summary, and he perhaps rather too modestly declares that he will not attempt to draw any definite conclusions from his material.

Recent Progress and Present Tendencies in Comparative Psychology, by ROBERT M. YERKES. Rep. from The Journal of Abnormal Psychology, February-March, 1908. pp. 11.

Yerkes makes four fields of comparative psychology which he would have studied comparatively: first, physiology of the central nervous system in relation to the behavior of organisms and to consciousness, such as the work of Sherrington and Franz; second, descriptive behavior, illustrated by Jennings and Bohn; third, the analysis of animal psychic processes, shown in works like those of Watson, Porter, Cole, and Berry; and lastly, discussions of the basis and method, such as the work of Claparède, Washburn and Yerkes. The most recent works of each of these authors are briefly described.

A Non-Surgical Treatise on Diseases of the Prostate Gland and Adnexa, by G. W. OVERALL, M. D. Rowe Publishing Co., 1906. pp. xii, 228.

This is the third edition of a work which advocates local and constitutional medication, and the application of electrolysis and cataphoresis, in place of operation, for the diseases mentioned in the title. While the author deplores the current tendency to surgical interference, he is careful to insist on the necessity of training and instruction in the use of electrical therapeutics. The book is the outcome of more than twenty years of clinical experience. The present edition describes three important and novel modes of treatment.

S. P. WORTHING.

The Greek Verb Graphically, by W. SIHLER, A. M. *The German Noun: Its Difficulties Simplified*, by W. SIHLER. Decorah, Iowa.

The first of these pamphlets represents an attempt to teach the Greek conjugation graphically, by means of simple geometrical figures. The author argues that, at the time when Greek is learned, the eye has already received training from drawing and geometry, while visual memory is also better than auditory. Some hundred diagrams, printed in two colors, together with a page of endings, provide the necessary material.

The second pamphlet gives rules for German genders and plurals taken from Kaeding's *Häufigkeitswörterbuch*, with some mnemonic helps for irregular forms, materials for exercise, and a vocabulary.

G. PARTEN.

Ueber einige Berührungstäuschungen. Von F. KIESOW, 1907.

Ueber einige Streitpunkte auf dem Gebiete des Geschmacks. Von F. KIESOW, 1907.

Sulla presenza di organi del gusto nella parte laringea della faringe, nel tratto cervicale dell' esofago e nel palato duro del feto umano. Nota del Dott. M. PONZO, 1907.

Sulla presenza di calici gustativi in alcune parti della retrobocca e nella parte nasale della faringe del feto umano. M. PONZO, 1905.

Intorno alla presenza di organi gustativi sulla faccia inferiore della lingua del feto umano. M. PONZO, 1907.

Contributo al problema della localizzazione delle sensazioni. Di M. PONZO, 1905.

(1) Reprint from *Arch. f. d. ges. Psychol.*, X. Deals in the main with an illusion of touch; when the acuity of localization is determined by Weber's method (retouching by the observer of a point already touched by the experimenter), it often appears as if the first touch (the cue to localization) were given not by the experimenter but by the observer himself. The paper describes various modifications and seeks to determine the conditions of the illusion. (2) Reprint from *Zeits. f. Psychol.*, XLV. Review of W. Sternberg, *Geschmack und Geruch.* (3), (5) Reprints from *Anatomischer Anzeiger*, XXXI, XXX; (4) reprint from *Giornale della reale Acc. di Med. di Torino*, XI; describing and figuring taste-beakers in the regions indicated in the titles. (6) Reprint from *Atti del V. Congresso intern. di Psicologia.* In cases of 'lingual inversion' (reversion of the tongue from left to right), localization is accurate under the abnormal circumstances, the direction of movement is subjectively reversed, and a form of Aristotle's experiment is possible. Similar experiences occur on the pinna of the ear, scrotum and penis. W. JENKINS.

Transactions of the Congress of American Physicians and Surgeons. Seventh triennial session held at Washington, D. C., May 7, 8, and 9. Published by the Congress, New Haven, Conn., 1907. pp. 164.

The papers here printed are grouped under two heads: first, the historical development and relative value of laboratory and clinical methods in diagnosis, and the four papers here printed are prepared by Drs. Osler, Barker, Stengal and Cabot; the second group is on the comparative value of medical and surgical treatment of the immediate and remote results of ulcer of the stomach by Drs. Muser, Stockton, Mayo and Munro. The address of the president, Dr. R. H. Fitz, treats of the borderland of medicine and surgery.

Diseases of the Heart and Aorta, by THOMAS E. SATTERTHWAITE. E. R. Pelton, New York, 1905. pp. 304.

The author tries here to place before the general practitioner a brief, simple, but practical presentment of cardiac and aortic affections from his standpoint of his personal experience. Over a hundred cases from his records are given at length. Little space is devoted to the anatomy or surgery of the heart, to its parasites, or to congenital anomalies or tumors. The book is based on a series of articles which originally appeared in medical journals, and appears to be a very valuable collection of precepts.

Wissenschaftliche Beilage zum zwanzigsten Jahresbericht (1907) der Philosophischen Gesellschaft an der Universität zu Wien. Johann Ambrosius Barth., Leipzig, 1908. pp. 42.

Wege und Ziele psychiatrischer Forschung, by R. GAUPP. H. Laupp-'sche Buchhandlung, Tübingen, 1907. pp. 28.

Ueber die Nachwirkungen der Vorstellungen, by W. SCHAEFER. O. Kindt, Giessen, 1904. pp. 44.

Die pseudomotorische Funktion der Hirnrinde, von RICHARD STERN. Franz Deuticke, Leipzig, 1905. pp. 27.

Faith in Man, by GUSTAV SPILLER. Macmillan Co., New York, 1908. pp. 190.

Travaux du Laboratoire de Recherches Biologiques de l'Université de Madrid, Tome VI, fascicule 3°, Août, 1908. Edited by S. Ramón y Cajal. Nicholas Moya, Madrid, 1908. pp. 97-160.

Pragmatism, by PAUL CARUS. The Open Court Pub. Co., Chicago, 1908. (Rep. from The Monist, July, 1908. pp. 321-362.)

Index of 1180 Post-Mortems of the Insane, by H. J. SOMMER. Published by the Board of Trustees of the State Hospital for the Insane, Norristown, Pa., 1908. 316 p.

L'évolution du Psychisme, par HENRI PIÉRON. Éditions de la Revue du Mois, Paris, 1908. 24 p.

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